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THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

JANUARY 1924

SOCIETY OF AUTOMOTIVE ENGINEERS INC.
29 WEST 39TH STREET NEW YORK

FOUR WHEEL BRAKES *and* FOUR SPRING BRAKES

The purpose of wheel brakes is to control horizontal movement
The purpose of spring brakes is to control vertical movement

TO ENJOY true motoring controllability, it is just as important to control vertical movements as to control horizontal movements. If spring recoil is permitted to throw the body weight up and off the wheels, the wheels then have less ability to adhere to the ground and the wheel brakes are then rendered partially or almost totally ineffective. The wheel brakes will stop the wheels; but if there is lessened adherence between wheel and road, the car will continue in its horizontal flight almost as though no wheel brakes had been applied.

Watson STABILATORS keep the body weight from being thrown up and off the wheels at all times, for the simple reason that STABILATORS resist each recoil force in proportion to that force. No matter to what extent the car springs may have been compressed, STABILATORS are immediately on the job with the *proper* amount of braking resistance to control the upward throw.

The imposing list of cars now factory-equipped with STABILATORS is your justification for a thorough investigation into the unique STABILATOR principle. STABILATORS have been on the market but two short years, and yet they are rapidly on their way to first place as a standard equipment feature; already eleven makes of cars are equipped.

JOHN WARREN WATSON COMPANY
Twenty-fourth and Locust Streets
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WATSON
STABILATORS
Change the Whole Nature of Your Car

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THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Vol. XIV January, 1924 No. 1

Chronicle and Comment

Revolutionary Painting Methods

PAINT troubles have come to the fore in the past year or two as one of the most irritating of the industry's production problems. It is only logical that the demands for better materials, greater durability of finish and lowered production costs should result in considerable progress. In one important instance this activity has led to the development of painting materials of a character that is entirely new in the automotive field. These materials possess certain characteristics that are sufficiently advantageous to warrant a prediction that their introduction will revolutionize motor-car painting methods. The new materials and their use were discussed at a recent meeting of the Detroit Section which is reported on p. 90 of this issue.

Let There Be Mirth and Gaiety

THAT old adage about all work and no play having ill effect on John's mentality has exerted its influence upon the plans for the Annual Meeting in Detroit. In this instance the playful atmosphere will be injected into the week's proceedings in the form of The Dance Carnival. This colorful gem of entertainment will be held on Wednesday evening, Jan. 23, at Oriole Terrace, Detroit's most beautiful temple erected to the Goddess Terpsichore. Table reservations come tumbling into the New York City office with every mail and indicate that this particular Carnival will be the largest ever held by the Society. More of the details are presented on p. 80 in this issue of THE JOURNAL. Read them, tell the story to your fair lady and order your table reservations at the earliest possible moment.

On to Detroit

THIS is Annual Meeting month! All eyes turn toward the hub of the industry as the S. A. E. Clan meets in Detroit, Jan. 22 to 25. A summary of the many features scheduled for this important meeting is given on p. 78 of this issue of THE JOURNAL. It is safe to say that the value of most of the papers is sufficient to more than repay a busy executive for the time and the money expended in attending the sessions. Four-wheel brakes, crankcase-oil dilution, new engines, motorbus design, numerous papers on body engineering and production topics and sessions on aeronautics are among the outstanding features. All meetings will be held in the spacious General Motors Building.

Reduced-fare concessions have been secured from the railroads tapping most of the automotive producing centers. Special arrangements have been made to assure hotel accommodations for those who send in their applications for rooms in advance. Detroit's largest Automobile Show will be in progress during the meeting period and our members are privileged to attend without cost. Turn to p. 78 and read all the other advance details.

Election of Officers for 1924

AS stated on the ballot blanks that were mailed to the Members early last month, the tellers of election of officers for 1924 will report at the 1924 Annual Dinner of the Society which is to be held at Hotel Astor, New York City, on the evening of the 10th of this month, at which time the Business Session of the meeting will convene. An adjourned business session is scheduled to be held in Detroit on the evening of Jan. 22.

London Automobile Headquarters

THE Institution of Automobile Engineers now occupies the second floor of Watergate House, York Buildings, Adelphi, London, W. C. 2. The offices are very accessible from the Charing Cross stations and the Strand. One room is devoted especially to the comfort of the members and their friends, a library including periodicals being maintained. Secretary Basil H. Joy, whom many members of the Society remember as a most welcome visitor to our shores in 1913, has graciously invited our members to make use of the London headquarters of the Institution of Automobile Engineers whenever they are in that city. The pride that Brother Joy expresses in the headquarters is well justified.

Head-Lamp Illumination Education

AT a recent meeting Secretary Meister, of the Mid-West Section, stated that probably 90 per cent of the head-lamps on automobiles in use are out of adjustment. This statement is apparently borne out by investigations that have been made by the Bureau of Standards. It seems that to improve the conditions greatly those charged with the administration of the motor-vehicle law in the various States will have to be

assisted by volunteer effort of representatives of various organizations such as automobile dealers' associations, service and garage associations, automobile clubs and safety councils, as well as manufacturing and engineering organizations connected with the automobile field. The Sections of the Society have taken a live interest in the matter and it is expected that suitable head-lamp-illumination educational exhibits will be made at most of the automobile shows this season. The Cleveland Section of the Society will participate in the conduct of such an exhibit at the Cleveland Show. The whole matter of inadequate or objectionable automobile illumination has become a controlling factor in the use of many cars. The American Automobile Association and the National Motorists' Association will furnish to local committees charts showing the necessities of the proper adjustment of head-lamps. Every garage that pretends to give adequate service should be equipped to adjust head-lamps properly. The head-lamps on all new cars should be adjusted before they are put into service. R. E. Carlson, of the Bureau of Standards, is devoting his entire time to the solution of the problem. All of the members of the Society, as well as the Sections thereof as units, are urged to support and participate in the work so far as this shall be feasible.

Standards Committee Division Reports

IN the reports of the Standards Committee Division chairmen that appear on p. 37 of this issue the work of the Standards Committee since the Summer Meeting is well summarized. These reports will be acted upon at the Standards Committee Meeting in Detroit on Jan. 22. The work involved in the formulation of the division reports may well be appreciated from the fact that during the year 50 Division and Subdivision meetings were held in the different automotive centers, 53 recommendations were formulated, 42 subjects were discontinued as not being possible or feasible to standardize and 55 subjects were assigned or renewed, there being 77 subjects in progress before the 27 Divisions of the Standards Committee at the present time.

That the Standards Committee is truly representative of the automotive industry in standardization matters is indicated by the fact that the total personnel is 425. Of these, 248 are Division members, 61 conferee members and 116 Subdivision members only. The total personnel of the Subdivisions is 244, as there are 128 Division members also serving on them.

The definite recommendations contained in the reports of the Division chairmen should receive careful study prior to the Annual Meeting. As stated in the introduction by Chairman E. A. Johnston, director of engineering of the International Harvester Co., "The creation of standards should be satisfying to all committeemen who have worked upon them because the results are of real consequence and value. The industry as a whole should further support their efforts."

Important Sections Matters

QUESTIONS now before the Special Committee on Society and Sections Organization, appointed by the Council to study the welfare and efficiency of the Sections of the Society, relate to reestablishment of a form of Section affiliation similar to that of the Section Associate enrollment that was in force several years ago, the putting into force of automatic Section membership of Society members residing in the respective Section territories and methods of supporting financially and maintaining as efficiently as possible the activities of the Sections. These problems involve various other matters, all of which will probably be discussed at the Business Session of the 1924 Annual Meeting of the Society in Detroit this year.

The committee has received recently expressions of opinion from 60 or more members of the Society, as well as from Sections and their Governing Committees.

Increase of National Dues

Typical reasons advanced in favor of increasing the annual dues of the Society, with reference particularly to providing funds for the maintenance of Sections activities, are

As the members of the Society as a whole receive most of the information made available by Section meetings, the members as a whole should defray the expense.

The plan would result in increased Section membership rather than in decreased Society membership.

The amount of the increase in dues would be negligible in view of the benefits available.

Compulsory membership in the Sections would stimulate attendance at the Section meetings.

The members as a whole are now being taxed through appropriations from the Treasury of the Society to the extent of over $600 per year per Section on the average.

Adding Section dues to the national dues would relieve the officers of the Sections of a large amount of work and effort and result in more activity and enthusiasm in the Sections.

The present "double" dues do not sufficiently tie the Sections to the national Society.

Raising Society dues to include Section dues is a practical plan of procedure in localities where Sections are already established.

It would be a very good thing to consider everybody within a reasonable radius of a Section center a Section member and assess him accordingly.

The scheme of increasing the annual dues in the parent Society sufficiently to permit from $5 to $7.50 being immediately passed on to the credit of the Section in which the member is located is the logical move.

The plan of collecting Section dues from all members seems to be perfectly proper and rational.

Arguments that have been advanced against increasing the Society dues are

Some members of the Society are not interested in Sections activities.

The Sections should be able to collect their dues from active and participating members.

Society dues are high enough now, especially as it is necessary to charge extra for TRANSACTIONS.

Increasing the Society dues would militate against increase in membership and in turn react to the disadvantage of the Sections.

Society members are not disinclined to contribute directly to the support of Sections that have demonstrated their merit. Their interest is generally stimulated more if they are called upon for support in the form of additional assessment.

Any attempt at coercive measures would result in unpleasant feeling on the part of many.

It is better to charge members for special benefits or privileges they desire, than to spread higher charges over groups of members without regard to benefits received.

The payment of Society dues should be optional not compulsory.

Increasing the annual dues and allocating members automatically to Sections would destroy all Section initiative and burden the Society with additional work.

The Sections should bear the difference between their

expense and the sums appropriated from the Society treasury.

Indifference rather than payment of Section dues keeps the average non-Section member from joining the local organization. To the indifferent member, enrollment in a Section at an increased cost will constitute nothing more than an increase in dues.

Section Associates

In the discussion as to the advisability of providing a basis for men to affiliate with Sections, receiving few or no privileges other than that of attending Section meetings, the following favorable opinions have been advanced:

Section Associates constitute a good recruiting field for new members of the Society.

The enrollment of Section Associates should be provided for, the fee therefor being not less than $5 per year.

It should be possible for persons who are interested in the Section activities, but not in those of the parent organization, to become affiliated with the Sections.

The enrolling of Section Associates in previous years resulted in increased attendance at Detroit Section meetings.

The only difficulty I recall that was experienced from enrollment of Associates by the Detroit Section was that the occasional Associate felt that he was a member of the Society. This caused slight confusion in connection with Summer Meetings of the Society.

It would be much better to kill the Section Associate idea entirely than to insist that a Section Associate, after a given period as an Associate, must become a member of the Society or cease to be a Section Associate.

Many people in each district would be anxious to become members of the Section, although ineligible for membership in the Society. These people would receive the principal benefit of the enrollment.

Some aspiring engineers are unable to pay the dues to the parent Society but would be very willing to pay the $5 "tuition" fee to the Section.

Section Associates with limited privileges would be desirable in carrying on the work of the Sections.

There are a large number of men who can benefit from local lectures, to whom payment of the initiation fee, together with $20 a year, is more than they can afford and would constitute too great a payment for what they would receive in view of the limited number of lectures that would be of interest to them.

Unfavorable reactions to the proposal included

Guests at Sections meetings are more apt to become members of the Society than Section Associates would be.

It should be at least somewhat difficult to become either a member of the Society or an affiliate of a Section.

Large attendance does not necessarily mean a successful meeting.

If a Section would be benefited practically to the same extent by enrolling Associates as by an increase in the membership of the Society, there would be less incentive for growth in the latter respect.

The Section Associate scheme would result only in unhealthy inflation.

No one interested in becoming a member of the Society should require an apprenticeship period to become acquainted with it.

Men enrolled as Section Associates would be placed in a false position. In spite of all verbal distinction, they would be admitted to a form of Section membership.

Men who are desirable as Section Associates should become Junior members of the Society.

It is doubtful whether it would be possible to avoid in the future the difficulties that arose in connection with the former Section Associates; also whether the benefit derived from Section Associates by the Sections or the Society would be worthwhile.

The force of the various arguments advanced will, of course, depend upon individual opinion and experience.

Miscellaneous

The following remarks were made by various members in connection with the whole discussion:

It has always seemed to me that the method of financing the Sections was excellent.

I am in favor of having the Society further in a financial way the growth of the Sections and their development, to an extent to be determined by comparing the costs of running and the receipts of the various Sections.

The Sections should by all means finance their local operations so far as possible. The main issue is for each Section to be absolutely sure of the need for help before calling for it.

Probably no phase of the Society's work is of more direct benefit than the Section activities, when they are intelligently conducted.

The Society might well put into Section matters sums that have heretofore been credited to the surplus account. The Society has already laid aside a substantial surplus and there is no need for increasing this surplus from year to year.

The parent Society should, as in the past, foster and financially support the Sections.

All members of the Society benefit from Section activities and there is full justification for some appropriations from the general Treasury for Section expenses.

The budget should be proportional unless some field promises greater yield.

I am strongly opposed to extending to anyone credit for membership dues for over 30 days. If dues are not paid within this time, all privileges should be automatically cut off.

Many of the Sections are now holding meetings that compare favorably with those held by the Society itself, so far as the character of the papers and the discussions are concerned. There are, however, still many Section meetings for which the papers are hastily prepared and of little real value to those who attend the meetings or read the reports thereof.

The Sections should not be asked to support any activity in which only a small portion of their members are directly interested.

In general, the opinion appears to prevail that the subjects discussed at meetings of the Society should be more diversified. This indicates that the old method prevailing several years ago was in general more satisfactory. Under it, the members felt under obligation to present to the Society new information acquired by them, whereas under the present system the feeling somehow prevails that a member does not owe any obligation to present information to the Society upon request.

Speakers of renown, whom we must have, are entitled to a large attendance. This can seldom be attained except by drawing from the outside under present conditions.

The old contention that Section papers should be printed in advance of the meeting and circulated to secure a good discussion is as pertinent as ever.

One thing that has impressed me as being wrong is the poor arrangement made for prepared discussion of the papers presented and the practice of allowing men to enter into the discussion of a subject of which they have very little knowledge.

If the Society devotes a portion of the time of its officers to the guidance and control of the Sections,

plus a portion of its money to the expenses, could not the Society benefit greatly through the consequent uniformly good Sections by receiving papers, the interest, the publicity and new members, as against the results that should be logically expected from localities where weak or loosely run Sections convey the impression that the Society is "no great shakes"?

If the Sections cannot stand on their own feet, it is a pity. I have always felt that the Sections should help the Society, rather than that the Society should help the Sections, because, getting back to fundamentals, the existence of the Society is primarily for the advancement of automotive engineering, standardization and the good of the industry at large.

The Society should be more aggressive in enlarging the membership of the Sections. The Sections have been largely allowed to shift for themselves. A strong effort should be made to convince the Society members of the tie-up between the Sections and the Society and of the importance of the Sections activities.

Section activity to be successful must be very closely tied-up with the parent organization's policy and operations. The Council of the Society has a definite responsibility in this connection.

To stimulate interest locally and to secure attendance at the meetings a mailing list of men who would be interested in the meetings should be made up and notices mailed to them regularly.

From comments made to me on the benefits of Society membership, I find that THE JOURNAL comes first by a large majority.

Assessing all Society members residing in Section territories would release funds now spent by the Society for Section affairs so that it would be possible to re-establish the distribution without extra charge of TRANSACTIONS to the members upon request, and the Society dues would not have to be greater.

I am not at all favorable to confining the jurisdiction of the various Sections to such small territories as in the past.

PANAMA CANAL

CLOSE to 60 per cent of the cargoes that pass through the Panama Canal, in point of tonnage, originate either on the Pacific or the Atlantic seaboard of the United States; and of this 60 per cent, approximately one-half moves in the coastwise trade and one-half is destined for foreign ports. Year by year the American coastwise traffic is becoming more and more important, judged by the tonnage and number of ships, the cargo tonnage and the variety of products carried in the water trade. The relative importance of various trade routes shifts sharply from year to year, responding to the conditions that affect international commerce, but proving nevertheless that the use of the Canal itself in world commerce is not yet stabilized.

The calendar year 1922 was by far the biggest in the history of the Canal. Before 1922 cargo traffic through the Canal was on three very clearly defined levels, the first in the fractional year 1914 and the years 1915 and 1916, when the movement was at a rate something less than 5,000,000 tons a year; the second in 1917, 1918 and 1919, when tonnage moved at a rate of from 7,250,000 to 7,500,000 tons a year; and the third in 1920 and 1921, when the level was in the neighborhood of 11,000,000 tons.

The year 1922 showed another big increase, more than 3,000,000 tons over 1921 and more than 6,000,000 tons over the level of 1917, 1918 and 1919. This was due chiefly to a tremendous increase in the volume of United States coastwise shipping, which amounted to less than 2,000,000 tons in 1921 and to nearly 4,000,000 tons in 1922.

Cargo tonnage from the east coast of the United States to the west coast was more than twice as great in 1922 as in 1921, and shipments from the west coast to the east coast were almost 100 per cent greater last year than in the year before. The increase in the east-bound tonnage was due largely to remarkable increases in the volume shipment of two important Pacific Coast products, lumber and crude oil. Since the beginning of 1923 the volume of Pacific-to-Atlantic oil shipments has been increasing. In March, 45 American tankers carried 511,699 tons of oil, more than half as much again as in the entire year 1922, to the east coast. The 1,000,000-ton increase in shipments from the east coast to the west coast was accounted for chiefly by a greater movement of manufactures of iron and steel, machinery and railroad materials.

Shipments from the west coast of Canada to Europe have grown remarkably in the last 3 years, increasing from 129,909 tons in 1920 to 252,684 tons in 1921 and 661,769 tons in 1922. This was due largely to greater cargoes of lumber and wheat. Greatly decreased shipments of beef, mutton, tallow and other products in cold storage, consigned almost entirely to the British Isles, account for the drop in tonnage in the Australia-to-Europe route in 1922 as compared with 1921. The *Panama Canal Record* takes this as an indication that the cold-storage movement has taken another sea route to England, rather than that exports from Australasia to the mother country have declined.—Mercantile Trust Co. of California's Monthly Review.

AIR-CLEANERS FOR TRACTORS

THE study of tractor engine air-cleaners at the California agricultural experimental station apparently solved the problem of air-cleaners for certain conditions in California. But it became evident that more should be known about air-cleaners to meet conditions in general. This led the Alabama station to study the problem from the viewpoint of its general applicability, and the conclusion was drawn that the logical starting-point of such a study is the dust itself, since it is obviously the most vital factor. A study was then undertaken to learn something first of the fundamental principles governing the existence and the movement of dust in an air-cleaner and under engine-intake conditions, to serve as a basis of methods for its maximum removal from the tractor air-intake within a given range of partial vacua caused by the intake suction and within a given range of amount and of physical, mechanical and chemical composition of the dust. As far as can be learned, the tentative conclusion drawn by the station and by one of the larger private research agencies, working in cooperation, is that the air-floated dust causing trouble is of colloidal fineness, and that after so-called decolloidization or flocculation it is subject to control by known mechanical principles. The problem apparently now is to determine the factors governing the flocculation of air-floated dust under such conditions. While the above statement of progress results may not be absolutely accurate, it serves, on the other hand, to indicate an effective way of bringing agricultural engineering facts of universal application to light. The purpose of the work mentioned is evidently not to show what method of dust removal of those known and available is best but to indicate the principles that, when embodied in any air-cleaner, will cause the maximum dust removal under the conditions imposed.—From an address by R. W. Trullinger, before American Society of Agricultural Engineers.

The Essentials of a Successful Constant-Compression Engine

By C. E. SARGENT[1]

ANNUAL MEETING PAPER *Illustrated with* PHOTOGRAPH AND DRAWINGS

THE efficiency of internal-combustion engines increases with the pressure of the charge at the time of ignition. Therefore, a compression at full load just below that of premature ignition is ordinarily maintained. But when such an engine is controlled by throttling, the efficiency drops as the compression is reduced, and as automobile engines use less than one-quarter of their available power the greater part of the time, the fuel consumption is necessarily high for the horsepower output.

On account, also, of the rarefaction due to throttling, more power must be developed than is necessary to drive the car; automobile engines in which the fuel is introduced during the induction stroke, would be more efficient, therefore, if the maximum compression were constant during all ranges of load. In the design under consideration this feature is accomplished by allowing free air, or the products of combustion, when the engine is running at less than full load, to enter the cylinder first, and the gas charge last so that it will be adjacent to the spark-plugs at the ignition time. By designing the combustion-chamber so that it will maintain a stratified charge during compression, ignition is effective, irrespective of the number of heat units introduced or the mean effective pressure desired. In the gasoline fuel at present available the induced charge is composed mostly of air with liquid spheres floating in it, so that violent agitation during the heat of compression is necessary to convert the liquid particles into gas; but the time is so short that, even with the maximum amount of perturbation, a considerable part of the fuel content is unconsumed.

While turbulence seems necessary for ordinary variable-compression prime-movers, it would be fatal to a

[1] M.S.A.E.—Research engineer, Bryan, Ohio.

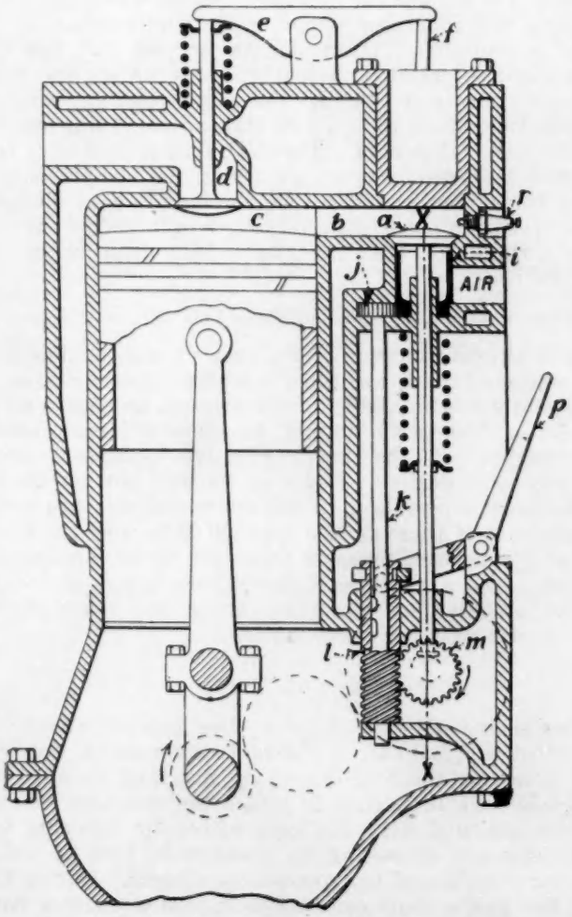

FIG. 1—SECTION THROUGH THE COMBUSTION-CHAMBER OF A CONSTANT-COMPRESSION ENGINE USING A REVOLVING DISTRIBUTING-VALVE

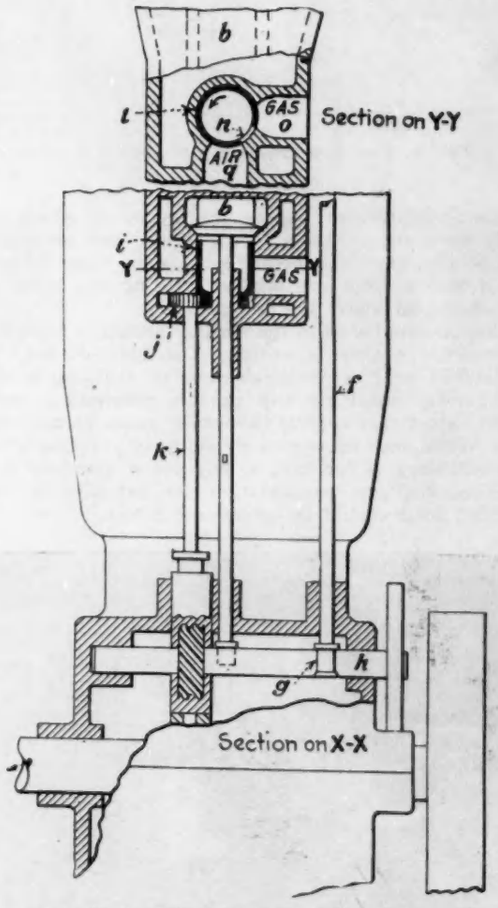

FIG. 2—SECTIONAL ELEVATION THROUGH THE VALVE AND THE DRIVING MECHANISM WITH A HORIZONTAL SECTION THROUGH THE DISTRIBUTING-VALVE AND THE GAS AND AIR PASSAGES ABOVE

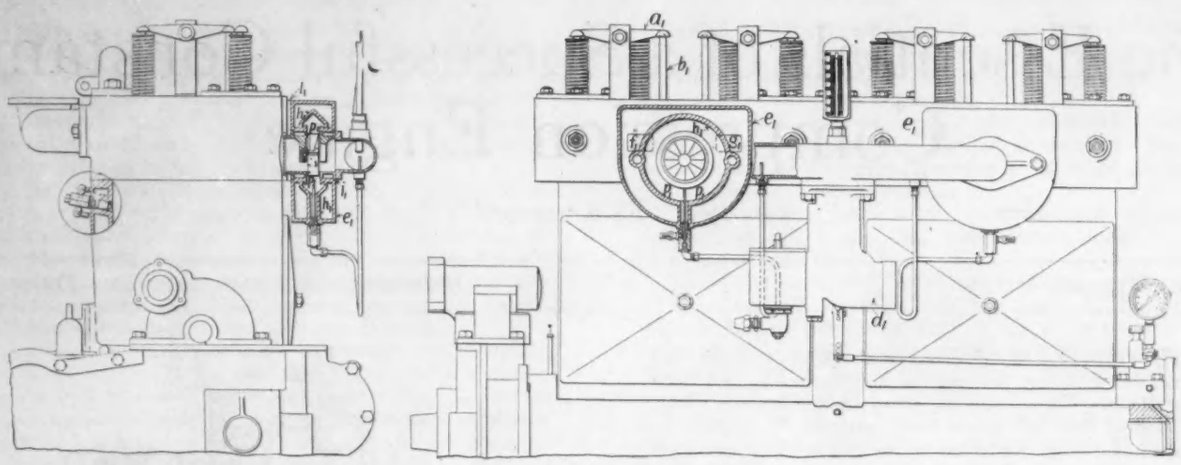

FIG. 4—END ELEVATION AT THE LEFT AND AT THE RIGHT A SIDE ELEVATION OF THE CONSTANT-COMPRESSION ENGINE SHOWN IN FIG. 3

constant-compression engine the cycle of which depends upon stratification. To operate such an engine successfully, the fuel, before admission, must be converted into a fixed gas without raising the temperature of the air above the dew-point.

When accomplished in the manner shown, a constant-compression engine is entirely feasible. It may be constructed with a distributing-valve that varies the time during which air and gas are admitted or with poppet-valves that control the intake gases in the same way. While such an engine should have practically the same efficiency at full load as engines of standard construction, the fuel consumption per car-mile on less than full load should be considerably less.

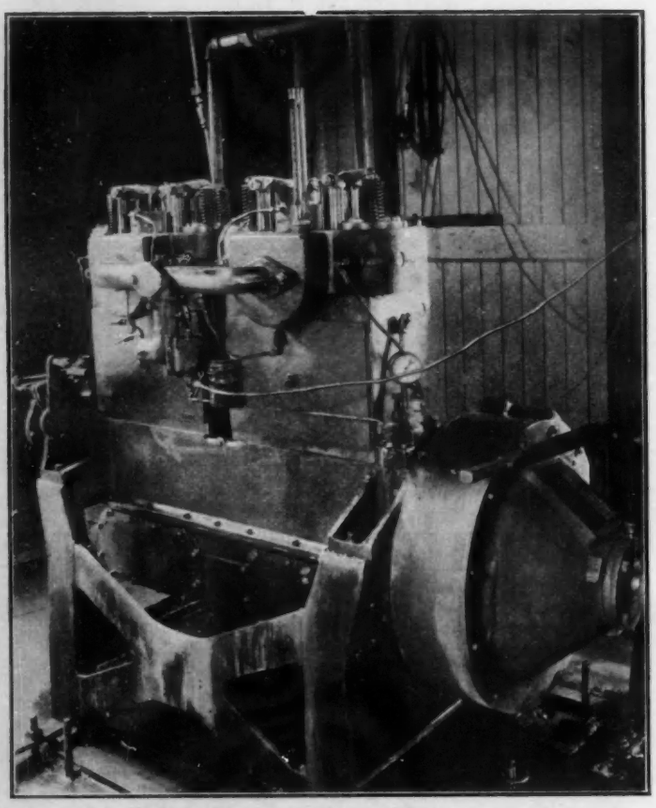

FIG. 3—THE EXTERIOR OF THE CONSTANT-COMPRESSION ENGINE USING POPPET-VALVES FOR THE ADMISSION OF THE AIR AND THE FUEL

THE only method now employed for controlling the speed of an automobile engine is throttling the intake, thereby reducing the quantity of explosive mixture admitted to the cylinders. While this method could hardly be improved upon for simplicity, it has two serious disadvantages that are recognized by the engineering profession.

Throttling the mixture to reduce the speed and load lowers the compression, a condition conducive to inefficiency, and reduces the absolute pressure above the piston during the induction stroke, materially increasing the fuel consumption. If, in running on less than full load the absolute pressure in the intake is 7.5 lb., the mean effective pressure during the corresponding working stroke would have to be 7.5 lb. higher than if this braking effect were eliminated. The desirability then of a constant-compression engine, in which the compression is just below the critical point of preignition at all loads and speeds, is apparent, especially in automobile engines, which run at less than one-quarter load about 90 per cent of the time.

THE DIESEL TYPE

The ultimate solution of the problem will, no doubt, be an engine of the Diesel type, in which the compression is inherently constant, but, for the present, an engine using available fuel, with normal but constant compression irrespective of the mean effective pressure, seems greatly to be desired. Reducing the fuel but not the air would solve the problem, if the attenuated mixture would ignite, but if there is less than 50 B.t.u. per cu. ft. of air at atmospheric pressure there will be no flame propagation; such a mixture, if the engine ran at all, would cause irregular and spasmodic firing, and much of the fuel would pass out unconsumed.

EXISTING TYPES

Decreasing the clearance as the induced charge is throttled will maintain a constant compression, but will not overcome the loss caused by manifold rarefaction. Engines have been built in which the clearance volume can be changed with the load, either by lowering the cylinder-heads or raising the crankshaft, both of which are too complicated for commercial success. During the last few years many constant-compression engines have been described and a few constructed, but to my knowledge none is in production.

A Proposed Cycle

If, on less than full load, we admit pure air, or the products of combustion, during the first part of the induction stroke, and a pure combustible during the last part, with a properly designed or proportioned clearance space, the fuel will remain adjacent to the ignition points when the spark is passed, yet the compression will remain constant at all loads, and there will be no wire-drawing or rarefaction above the pistons during the induction stroke. By varying the ratio of the products of combustion, or of the pure air to the fuel, any load within the capacity of the engine can be carried, while maintaining at all times the predetermined compression.

A New Type

To prove that an engine operating on such a cycle could be designed to maintain a constant compression and a mean effective pressure commensurate with the load, and yet effectually ignite the charge during all ranges of horsepower output, a four-cylinder 4 x 6-in. Erd engine was rebuilt to incorporate a valve mechanism similar to that shown in Figs. 1 and 2. The inlet poppet-valve *a* opens into extension *b* of the clearance space *c*, similarly to the practice in conventional L-head engines. The exhaust-valve *d* is operated by the rocker-arm *e*, the tappet *f* and the cam *g* on the camshaft *h*. Both inlet and exhaust-valves have conventional timing. Under the intake-valve *a* is the cylindrical rotatable distributing-valve *i*, driven by the spur-gear *j*, the shaft *k* and the spiral-gear *l*, meshing with the driving-gear *m* on the camshaft *h*. At full load the distributing-valve port *n* registers with the gas port *o* during the lift of the intake poppet-valve *a*, delivering only a pure mixture to the combustion-chamber.

As the load gets lighter and less mean effective pressure is required to maintain the speed desired, the distributing valve *i* is retarded in time with reference to the opening of the poppet-valve *a* by the control handle *k*, raising and rotating the spiral-gear *l* until the port *n* partly registers with the air-port *q*, when the valve *a* opens, permitting a charge of pure air to scavenge the clearance and pass down with the piston. Before the valve *a* closes, the gas passage *o* will register with the port *n*, permitting a charge of pure gas to enter and remain adjacent to the spark-plug *r* during compression. Any ratio of pure air to inflammable gas may be obtained by adjusting the lever *k*.

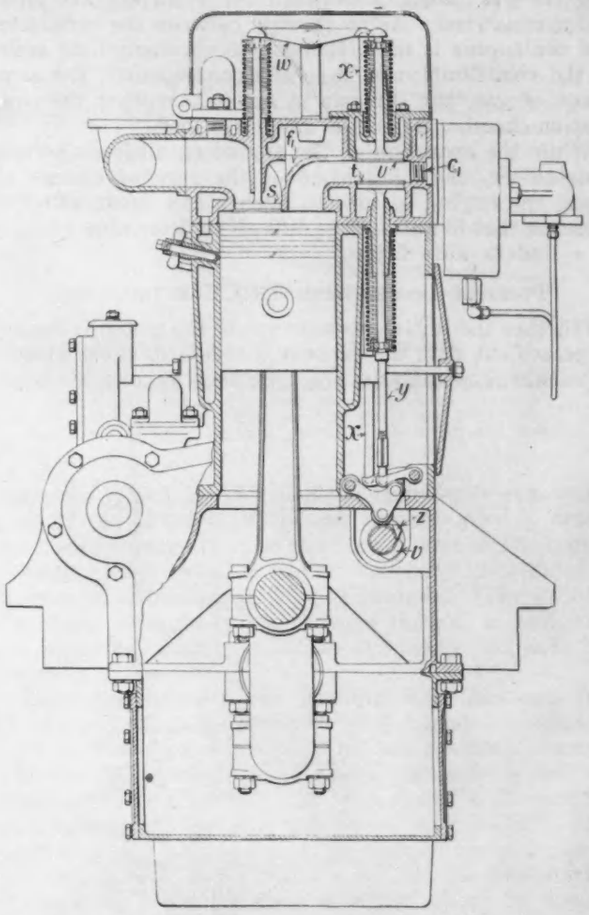

Fig. 5—Section through the Cylinder and the Combustion-Chamber of the Engine

By rotating two distributing-valves in one direction and two in the opposite direction, the lever *k* is balanced,

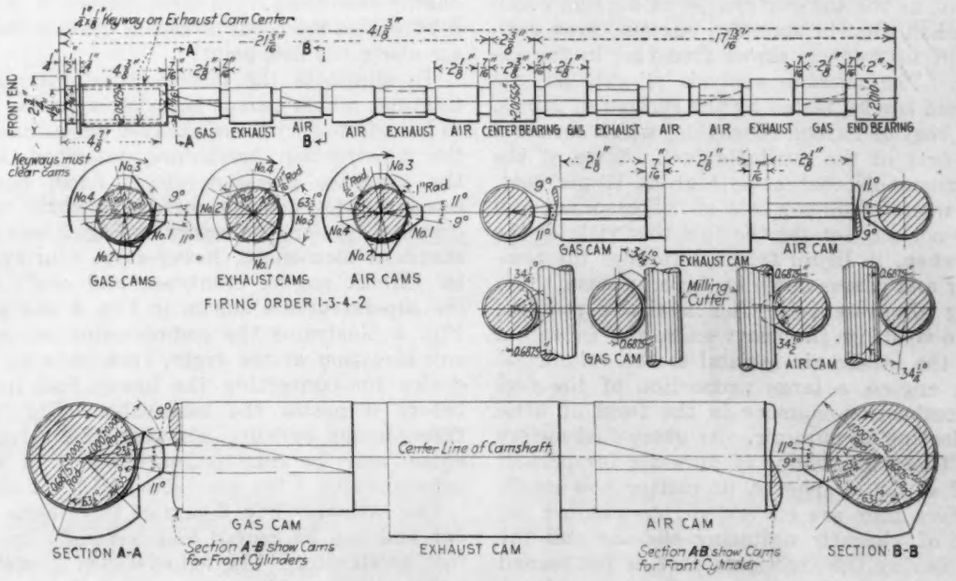

Fig. 6—Details of the Camshaft of the Engine

and the gas passages between the cylinders are short and symmetrical. As no throttle between the carbureter and the engine is used, there is no rarefaction to assist in the volatilization of the fuel; consequently, the same grade of gas, but variable in amount, reaches the combustion-chamber during all ranges of load.

While the operation of the engine on all loads seemed satisfactory, the elimination of the rarefied charge allowed the engine to idle on such a low mean effective pressure that it was at first difficult to determine whether all cylinders were firing.

Possible Losses with This Construction

Whether the initial gas adjacent to the piston is burned or passes out with the exhaust is indeterminable without an exhaust-gas analysis, and even such an analysis would not be conclusive, as the induced charge of air and available gasoline, when used in standard engines, even with a high degree of turbulence, shows free fuel in the exhaust products. The average analysis of exhaust gas from 101 cars and trucks, tested by the Bureau of Mines, showed 6.5 per cent of carbon monoxide, which means a loss of 30 per cent of the available fuel. Some of the cars showed a monoxide content as high as 13 per cent, which means a waste of 50 per cent of the gasoline; and these figures do not account for the fuel that vitiates the lubricating oil when, in liquid form, it reaches the combustion-chamber and passes down to the crankcase.

As practically all present-day fuel available requires 500 deg. fahr. to volatilize the heavy ends, and as such a temperature of the intake air is fatal to the volumetric efficiency of an engine, a large proportion of the fuel passes to the combustion-chamber in the form of little liquid spheres floating in pure air. As every fuel sphere requires 10,000 times its volume of pure air for perfect combustion, and as liquid spheres, no matter how small, cannot burn before they are converted into gas, we see the desirability of violently agitating the air and the liquid particles, during the fractional part of the second that the heat of compression is available, to break up these liquid spheres by attrition into a mixture approaching a fixed gas.

Turbulence increases the thermal efficiency in an internal-combustion engine, except when natural or a fixed gas is used for fuel, yet no matter how violently the induced charge is agitated, when it is composed of liquid fuel and air, the time of gasification is so short that there will still be unburnt liquid at the end of the combustion stroke to contaminate the crankcase oil and develop carbon monoxide to be rejected in the exhaust.

Stratification Necessary for Constant Compression

A constant-compression cycle depending upon a stratified charge cannot succeed, then, unless this charge is composed of fuel in a gaseous, liquid-free state; therefore, one of the problems of a successful constant-compression engine depending upon stratification is to furnish it with a pure gas, from our available fuel, without heating the air above the dew-point.

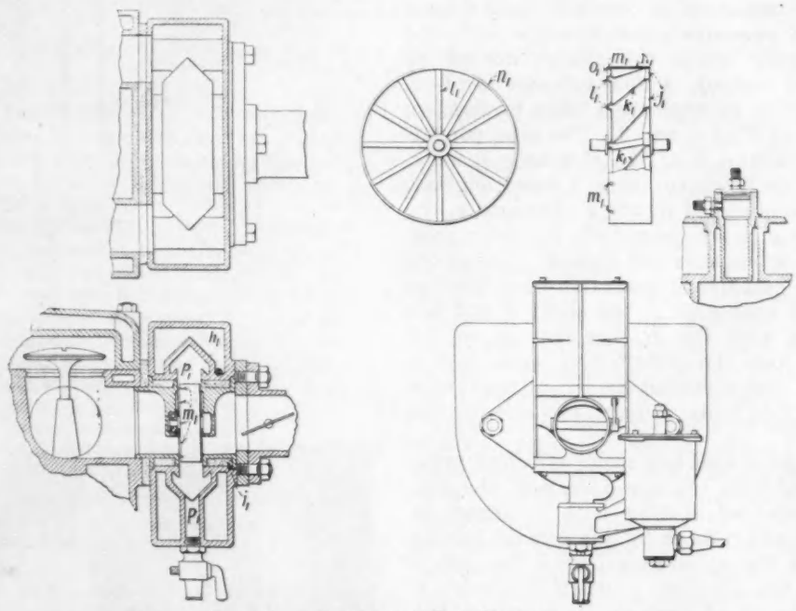

Fig. 7—The Fuel-Separating Fan Used on the Engine

Details of the Vanes or Blades Are Given in the Upper Right Corner, While the Application of the Fan to the Engine Cylinder Is Shown in the Remaining Views, a Section Being Reproduced in the Lower Left Corner

To eliminate the remote possibility of allowing the mixture, which passes into the cylinder before the air, to be rejected with the exhaust unconsumed, as shown in the construction heretofore described, and to convert the available gasoline into a fixed, homogeneous and comparatively cool gas before reaching the combustion-chamber, the engine shown in Fig. 3 was constructed. A standard slow-speed, heavy-duty, four-cylinder, 5½ x 7-in. Climax engine crankcase and shaft were used and the superstructure shown in Fig. 3 was placed on these. Fig. 4 illustrates the end-elevation at the left and the side-elevation at the right, each showing in section the device for converting the heavy fuel into a fixed gas before it passes the inlet-valve. Fig. 5 is a section through one cylinder, showing the valves, valve mechanism and the combustion-chamber, in which s is the exhaust-valve, t the gas-valve and u the air inlet-valve.

The camshaft Fig. 6 carries three cams for each cylinder and can be moved longitudinally by a governor or foot accelerator. The exhaust-cam v operates the valve s through the rocker-arm w and the tappet-rod x. The

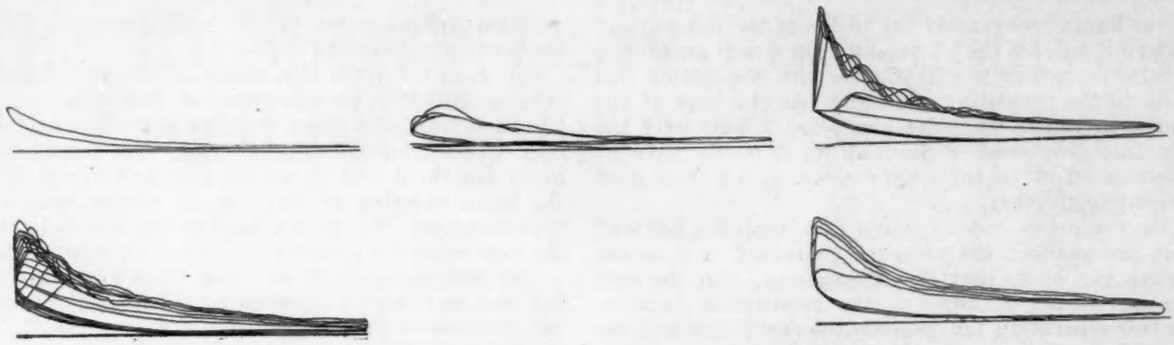

FIG. 8—REPRODUCTIONS OF INDICATOR-CARDS OBTAINED FROM THE CONSTANT-COMPRESSION ENGINE AT DIFFERENT LOADS

The Indicator-Card at the Upper Left Is an Idling Diagram from Cylinder No. 1, the Middle Card in the Upper Row Is Another Idling Diagram from Cylinder No. 1 with the Air-Valves Held Closed and the Card at the Upper Right Was Taken as the Full Load Was Thrown Off and Shows a Constant Compression but a Variable Mean Effective Pressure. The Indicator-Card Reproduced in the Lower Left Corner Shows an Ignition Timing That Is Too Early for Full Load and Too Late for Idling, While in the Card at the Lower Right the Time of Ignition Was Advanced as the Load was Reduced

gas-valve t is operated by the tappet y and the tapered cam z. The air-valve u is operated by the rocker-arm a_1, and the tappet b_1, Fig. 4, and a cam behind z, Fig. 5, similar to it, but tapered in the opposite direction and on the opposite side.

The exhaust-valve has standard timing. The gas-valve at full load has standard timing, but as the camshaft is moved endwise, the time of opening the gas-valve becomes later as the load gets lighter. The air-valve does not open at full load, but as the load decreases and the camshaft is moved to give less gas, the air-valve opens at the beginning of the induction stroke and closes shortly after the gas-valve has opened.

At less than full load pure air enters the combustion space first, then, for an instant, air and gas, and finally pure gas, which remains adjacent to the spark-plug located at c_1, during compression and ignition. To get quick and sufficient openings with the camshaft, the diameter of which was limited, toe cams were used under the tappets and the skirts on the poppet-valves, as shown in Fig. 5.

A constant-vacuum carbureter d_1, Fig. 4, supplied cold air and fuel vapor to a manifold branching to the head of each pair of cylinders. Between the manifold and the heads are bolted castings e_1, containing the pure gas-making elements. The outer chamber of this casting is open to the exhaust from cylinders Nos. 1 and 2 through the ports f_1 and g_1. When No. 1 cylinder is exhausting, part of the exhaust gas passes through port f_1, around the cored passage in e_1 to the port g_1 and to the regular exhaust exit of cylinder No. 2. When No. 2 cylinder exhausts, the direction of flow is reversed. The exhaust-gas direct from the cylinders keeps the wall h_1 sufficiently hot under any load to volatilize the heavy fuel-ends that reach it.

Supported between two bushings and insulated from the heat of the outer chamber by the insulating material i_1 is a 12-blade fan mounted on ball or plain bearings. This fan is rapidly rotated by the induced air and fuel flowing to the cylinders. It is designed with combination dampening-blades j_1 parallel to the fan-shaft, which tend to retard its speed, and the inclined blades k_1, shown enlarged in Fig. 7, so that the air and the fuel starting through must change their direction about 30 deg. before leaving the fan.

As the weight of the liquid spheres is over 600 times greater than that of an equal volume of air, inertia drives them straight ahead, causing them to impinge upon and spread over the surfaces of the inclined parts of the fan-blades, and the attrition of the air and inertia drives the liquid to the gutters l_1, upper right corner of Fig. 7, from which, by centrifugal force, it is thrown through the registered openings m_1, against the hot surface of the wall h_1, where the liquid fuel is converted into fixed gas,

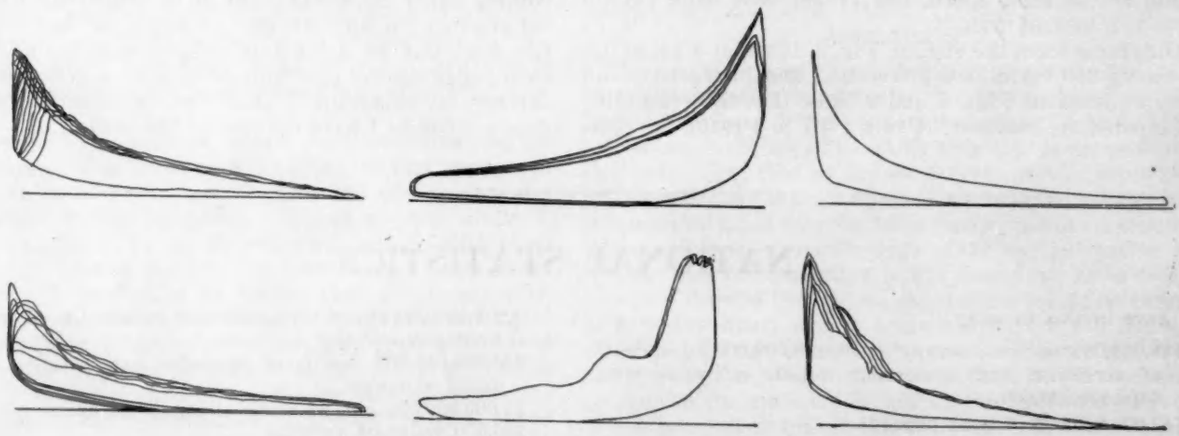

FIG. 9—ANOTHER SET OF TYPICAL DIAGRAMS OBTAINED WITH THIS ENGINE

The Indicator-Card Reproduced in the Upper Left Corner Was Taken at a Speed of 550 R.P.M. and a Variable Load; in the Upper Central Card, the Speed Was Increased to 600 R.P.M. and the Engine Was Fully Loaded; the Card in the Upper Right Corner Was Taken at a Speed of 500 R.P.M. and a Three-Quarter Load. The Diagram Reproduced in the Lower Left Corner Was Taken at a Speed of 500 R.P.M. and a Variable Load and the Lower Central Card, Like the One above It, Was Taken at Full Load and 600 R.P.M. The Card in the Lower Right Corner Was Taken at a Speed of 600 R.P.M. with Fixed Ignition Which Was Too Late at Light Load and Too Early at Full Load

If the liquid fuel reaches the inside of the fan-housing n_1 before it reaches the gutters, the lip o_1 will guide it to the holes m_1, where it will mingle with the gutter fuel and fly to the insulating chamber. As the heat of the exhaust, insulated from the airstream, affects only the liquid fuel that reaches the wall h_1, it would have no deleterious effect on the engine power if the fuel used were petroleum ether.

When the heavy ends of liquid fuel reach the hot wall h_1 and are gasified, the pressure generated in p_1 drives the pure gas back, past the fan-housing, into the cold airsteam, whence it flows to the combustion-chamber. With this separating fan between the carbureter and the engine block, there is no evidence of free fuel reaching the lubricating oil, and as only pure gas reaches the combustion-chamber, violent perturbation or turbulence is superfluous.

The engine governor, designed to operate a butterfly throttle, was not expected to move the camshaft longitudinally; it was, therefore, connected to a balanced relay-valve, shown in the right half of Fig. 4, through which the governor would vary the pressure of the lubricating oil between the end of the camshaft and the closed end of the camshaft bearing. The camshaft was held in the light-load position by a helical spring. With an increase of the load and a decrease of the speed, the governor would open the relay-valve, admitting a higher oil-pressure to the end of the camshaft, thus moving it to the position to give a greater mean effective pressure. While this governing system held the average speed constant, the racing or surging of the engine above and below this speed, caused by the sluggishness of the system, was prohibitive; hand control, therefore, was finally used in this engine.

The object of this experimental construction was to show that an engine could be made to operate on a constant compression for all ranges of load without missing an ignition, yet eliminating the rarefaction and braking effect found in standard engines using throttling control. At full load, the efficiency of such a cycle should be no better than that of the ordinary engine, other things being equal, but at light loads, at which the automobile more often operates, a saving in fuel should be effected. Compared with a standard 4 x 6-in. throttling engine of the same make as was used in constructing the engine shown in Fig. 1, the constant-compression engine, when idling at the same speed, ran 17 per cent more revolutions per unit of fuel.

Diagrams from the engine, Fig. 3, taken at a speed not to exceed 600 r.p.m., are interesting and instructive, and as reproduced in Figs. 8 and 9 show that the conditions anticipated are realized. Using a 4.7 to 1 ratio, the compression approximates 90 lb. gage pressure with full mean-effective-pressure range.

Fig. 8, at the upper left, shows an idling diagram from cylinder No. 1. The upper central view shows an idling diagram from the same cylinder and the same idling load with the air-valves held closed. The compression is about one-third that shown on the card at the left and the mean effective pressure in the central card equals, approximately, that in the card to the left, plus that of the loop below the atmospheric line in the central card.

The indicator-card at the upper right was taken as the full load was thrown off, showing a constant compression but a variable mean effective pressure. As the total number of heat-units admitted became less, inflammation or flame-propagation was slower, indicating that for the best efficiency the time of ignition should be materially advanced inversely as the load. The card at the lower left shows an ignition timing too early for full load and too late for idling. In the lower right diagram the time of ignition was advanced as the load was reduced.

Fig. 9 shows typical diagrams from this cycle and emphasizes the possibilities of a constant-compression engine.

Conclusion

Constant-compression engines in which throttling is eliminated are feasible if the construction permits the admitting of an inert gas at less than full load during the first part of the induction stroke and of a burnable gas during the last part, which will remain adjacent to the spark-plugs during the compression stroke. As stratification is essential for such a constant-compression cycle, the induced charge must not require violent agitation or turbulence to improve the gasification of the fuel. If turbulence is not permitted, the fuel must be converted into a fixed gas before it reaches the combustion-chamber, without heating the air above the dew-point. With a fixed gas entering the engine last during the induction stroke, ignition is as sure under a predetermined high compression as with the lower and variable compression of throttling engines, when turbulence causes a commingling of the products of combustion with the gas.

While the valve motion of a constant-compression is more expensive than that of a throttling engine, it is by no means prohibitive. The simplicity of a throttle-valve engine could hardly be improved upon, yet with thermal advantages possible and probable, constant-compression control could be worked out in a way that would be satisfactory to all. If the construction described and the essentials of a constant-compression engine, as set forth, open up the possibilities of such a cycle and start further investigation, I shall feel recompensed for the time and study I have devoted to the subject.

NATIONAL STATISTICS

We have in this Country

110,000,000 persons, occupying over 3,000,000 sq. miles of territory, and possessing wealth estimated at $300,000,000,000.

$40,000,000,000 of bank deposits.

$70,000,000,000 of outstanding life-insurance

500,000,000 acres of improved farm-lands, valued at $77,000,000,000

24,000,000 milch cows, 40,000,000 head of other cattle, 40,000,000 sheep and 60,000,000 swine

3,000,000,000 bu. of corn and 1,000,000,000 bu. of wheat produced annually

$60,000,000,000 worth of manufactured articles produced annually

24,000,000,000 gal. of crude oil produced annually

250,000 miles of railroad

250,000 miles of commercial telegraph lines

800,000 miles of telephone lines

20,000 daily and weekly newspapers—

Walter W. Head, president,
American Bankers Association.

The Engineer's Duty in Simplifying Electrical-Equipment Repairs

By J. W. Tracy[1]

Dayton Service Meeting Paper

SELECTION and application of the apparatus is stated to be the starting-point for the engineer in simplifying repairs to electrical equipment, and illustrations are cited to show that this is not a difficult matter today. The one outstanding feature that should dominate all effort along this line is accessibility; but if the repair is to be simple, the apparatus itself must be simple. Odd sizes and shapes must give way to commercial standards. Intricate assembly operations and complicated circuits must be simplified and the engineer should design apparatus for repair with simple tools, although special tools must be distributed also.

Maintenance of repair-parts stock, the necessity for a background of experience, the dissemination of technical information and of explicit service instructions for new apparatus are given brief consideration. The engineer can do most to simplify repairs when he has an intimate and personal acquaintance with the troubles and a just appreciation of his co-workers' recommendations.

UNFORTUNATELY for the equipment manufacturer, the demand for electric generators and starting-motors for automobiles came at a time in the development of the vehicle when electric starting and lighting was considered a refinement rather than a necessity. The passenger-car engineer's effort up to this time had been directed toward a design that would be practical and dependable and permit the rapid production made necessary by the increasing competition. Any attachment that did not contribute directly to the actual operation of the car was not looked upon by the engineers with any marked degree of enthusiasm. Moreover, the automobile had begun to crystallize into a general uniformity of design and appearance in which time and economic factors made redesign unwelcome and undesirable. Electric starting and lighting came in for its full measure of distrust and unpopularity in this respect. Contrast, for example, the status of the carbureter. As an essential component of the engine assembly, it was considered from the very beginning of the design. To be sure, its radius of location was limited but care always had to be exercised to permit access for adjustment and repair.

Consequently, when the demand for electrical equipment came, and it came over-night, there was little time and often little inclination to redesign the engine and the chassis for its reception. It was applied where it could be applied. To say that it was applied in the most convenient location would be in most cases a gross exaggeration. It was often so hidden that it almost defied detection and, when it was found, it was a long and arduous job to take it out to make repairs. It is a fact that in a number of installations it was necessary to lift the engine from the chassis to remove the starter-generator; and dropping the crankcase or taking off the radiator to make a minor electrical repair was a mere detail. Electrical repairs thus started with a bad handicap and, however much has been done by the engineer to improve this condition, considerable room for improvement still remains.

Selection of Equipment

Obviously, the starting-point for the engineer in simplifying repairs is in the selection and the application of the apparatus. While it may be true that the choice of the engineer in selecting equipment for any particular installation may have no direct bearing on the case or difficulty with which repairs can be effected, undoubtedly the electrical service-man's work is complicated seriously by the unsatisfactory performance of inadequate apparatus. No repairman, however expert, can hope to satisfy a car-owner when the generator has not the output to meet the demand of the starting and lighting system. He cannot make a puny starting-motor exert itself beyond its inherent capacity on a cold morning.

The selection of proper equipment in this day is not a difficult matter. Data from exhaustive tests and long experimentation by the electrical-equipment engineer, the automobile engineer and the battery engineer are readily available. There need be no guesswork in determining the torque required to crank the engine. Extreme conditions of operation are now reproduced in the laboratory, and the engineer can specify the power rating of the starting-motor with the assurance that the latter will meet all requirements. A simple calculation will determine the output of the generator necessary to keep the battery in condition to meet the demands of starting, lighting and ignition. The battery is of vital importance, yet is often dismissed with scant consideration. It should be selected in view of the duty it is to perform rather than of the space it is to occupy. The engineer can then make a good start in simplifying the lot of the repairman at least by selecting equipment that will do the work required with a fair margin of safety for the emergency.

Application

The application of the electrical equipment offers, perhaps, the greatest opportunity for the engineer in simplifying repairs. The one outstanding feature that should dominate all effort along this line is accessibility. It is safe to say that by far the largest part of the wholly unjust criticism that is directed against the service-man is caused by labor charges for which he is not responsible. For example, a car-owner calls at the service-station and reports that his generator is not charging; he is told to leave his car and the trouble will be corrected; he returns after a few hours and is presented with a bill listing a charge of $6 for labor and 60 cents for brushes. He is not any better pleased when told that it was necessary to remove the radiator to get at the brush-rigging. It is not unusual to find it necessary to drop the oil-pan to make minor repairs to the starting-motor or generator or even to make a preliminary inspection. When the electrical equipment is accessible, repairs simplify themselves because troubles are easily located and corrected before they become serious. A good example is found in the

[1] Vice-President and general manager, North East Electric Co., Rochester, N. Y.

distributor-board. It is rarely located now where it cannot be examined and repaired with minimum effort.

Unnecessary Styles and Sizes

If the repair is to be simple, the apparatus itself must be simple. Odd and unusual sizes and shapes of bolts, nuts and screws must give way to commercial standards. Intricate assembly operations and complicated circuits must be simplified. The engineer should design apparatus for repair with simple tools. Pliers, screw-drivers and standard wrenches are always at hand, but special tools must be distributed.

One of the most difficult problems the service-man has to contend with is maintenance of the repair-parts stock. On the 14,000,000 automobiles now in use there are over 1000 different designs of electrical equipment. On a very large percentage of these cars standardized equipment of one of the four rated capacities recently adopted by the Automotive Electric Service Association could be satisfactorily installed. One electrical manufacturer has over 400 different armatures to service, all for machines now in the field. The need here is obvious. Standardize to reduce the number of models and parts. Discourage unnecessary and minor changes in application and design. Where changes are necessary and desirable, a decided effort should be made to use parts common to apparatus already in use. Encourage development and research, but put new devices into service only when they represent and have proved to be a distinct and a desirable advance in the art.

Laboratory and Field

Satisfactory service is practically impossible when the car-owner field is made the laboratory. Unless a background of experience, built up through long and careful test of the new design before it is put into production exists, simplicity in its repair cannot be expected. The only hope is the ingenuity of the repairman; however skillful he may be, the general result cannot be satisfactory. Substitution of parts, usually of inferior quality because an economical genuine parts-stock cannot be selected except through experience, will occur. Replacement units for service are not practical for devices in the development stage. The service-station shelves may be loaded with units that will become obsolete before they can be used.

The matter of technical information is also brought into the situation. A simple repair cannot be expected from the service-man if he is confronted with a new and strange device. The general principles of operation of kindred equipment may be the same but, in apparatus with which he is not acquainted, the repairman finds that there are sub-assemblies and adjustments which have to be studied and guessed at, often with disastrous results. Time is lost in tracing out circuits, making and unmaking connections, final tests are based upon incorrect assumptions and the repair, simple in itself, is thus confused and complicated.

Information Service

The introduction of new apparatus should be preceded, or at least accompanied, by full and explicit information for its service. Repair-parts lists should be furnished the service-man. Such lists compiled as a result of experience with similar apparatus and of the observation of the new devices during development should specify the quantities of parts to be carried in a service stock. The service-man is not in a position to decide the matter. His natural inclination is to wait until he has a call for the part rather than to anticipate the need. Price-lists, with all parts plainly illustrated by cuts and definitely named and numbered, are of course a necessity, as well as sectional drawings of the apparatus in which the precise location of each part is shown. Drawings giving as nearly as possible the location of the particular equipment with respect to the other apparatus on the car should be provided. The car wiring can be incorporated in such a drawing; if a perspective or a graphic representation is used, so much the better. Internal-wiring diagrams are to be furnished, of course. Short-cuts in production repairs and assembly, changes in material, design and operating performance should all be carefully explained to the service-man from time to time as the occasion presents itself. While there may be some question as to whether the disseminating of this information comes within the engineer's province, it is nevertheless a fact that he is the source of the original data, and he can insist that his apparatus be given the benefit of his service.

The electric-equipment engineer can become more effective in simplifying repairs by becoming acquainted with them, and no better avenue or approach for this exists than through the service organization. Study and analysis of trouble reports will often point the way to a simple change in design that may not only simplify but perhaps entirely eliminate a repair. For example, an original third-brush adjustment on a generator was made by turning a hexagonal nut with a wrench. This was a simple operation until a change in carbureters by the car builder introduced interference which made the adjustment an expensive repair-job. When the engineer's attention was called to the complaints appearing in the service reports, a slotted head was substituted for the hexagonal head and the complaints disappeared almost immediately after the change was made.

The design of new apparatus and changes in the design of apparatus already in use can be benefited in practically every instance by reference to the service department's experience. Changes of any kind whatever, in production, design or material, should be submitted to the service department. Ninety-nine times the change may be of no consequence one way or the other, but the hundredth time it may be of great importance. A material or a finish that is highly satisfactory on the roads of New England may be worthless in fording the streams of West Australia. A small change in the size or the shape of a device may call for radical changes in test equipment throughout the whole field-service organization.

The simple and comprehensive answer to this question is that the engineer can do most to simplify the repairs when he has an intimate and personal acquaintance with the troubles and a just appreciation of his co-workers' recommendations.

Some Notes on Brake Design and Construction

By H. M. CRANE[1]

METROPOLITAN SECTION PAPER *Illustrated with* DRAWINGS

THE discussion following the presentation of this paper at the October meeting of the Metropolitan Section was entirely verbal, no written contributions being received from members who were unable to be present. In accordance with the usual practice the stenographic report has been submitted to the various speakers for correction and to the author for any additional comment that he cared to make and the discussion, as corrected and amplified, appears below. For the convenience of the members an abstract of the paper precedes the discussion with a reference to the issue of THE JOURNAL in which the paper was published so that those who desire to refer to the complete text can do so with a minimum of effort.

ABSTRACT

BRAKES have three functions: (*a*) maintaining a car at rest, (*b*) reducing the speed of a vehicle or bringing it to a stop, and (*c*) holding a vehicle to a constant speed on a descending grade. The kinetic energy of a moving vehicle is directly proportional to the weight of the vehicle and to the square of its speed. The amount of heat produced in the braking surfaces of a vehicle descending a given grade for a given distance will be the same whether the speed be high or low, but the rate of heat production will vary inversely as the speed. In addition to the retarding effect of the braking system a braking effect is constantly present that depends on the tractive resistance of the vehicle at various speeds and on the engine itself. Wind resistance and the resistance of the engine when the throttle is closed also produce retarding effects that assist in the work of braking.

Among the desirable features that should be kept in mind in designing brakes are (*a*) the maximum retarding effect with reasonable physical effort on the part of the driver, (*b*) smoothness of retardation, (*c*) a retarding effect proportional to the pedal pressure, (*d*) no tendency to be self-locking, (*e*) durability or long life, (*f*) ease and simplicity of adjustment, (*g*) strength, easy operation and thorough dependability and (*h*) brake-operating levers that may be easily and quickly reached in emergency.

The power available for operating brakes is a pedal movement of 4 to 5 in. coupled with a foot pressure that varies with the person operating the brake; consequently, brakes should be designed for the weakest driver. A properly designed mechanism will sometimes accomplish the same result with one-half the pedal movement that is required by another linkage of the same type but of inferior design. The linkage should be simple and direct, and the relation of the centers of the connections that operate the brakes on the axles and the wheels should be carefully studied so that the relative motions of the axle and the frame will not affect the linkage. If the major part of the multiplication of leverage takes place at the brake-drum the strains in the operating mechanism will be reduced to a minimum and the longitudinal motion will be increased to a maximum. In any design the two points to be kept in mind are a low rate of wear and a high rate of heat dissipation. In general, large linear dimensions are desirable but better air-circulation sometimes makes smaller sizes preferable. In light cars weight is of importance, while in heavy cars size is the controlling consideration. Unit pressures depend largely on the materials used; a brake-drum with hard surface with a lining of suitable material may enable higher unit pressures to be used than a soft surface with a lining inherently weak. Most brakes depend on either the external or internal application of shoes or bands. The features of the band type are light weight and a large friction-area. The external band is easier to design, as the anchor point can be placed in any position desired. To obtain smooth action and long wear from a shoe-type brake, rigidity of both the drum and the shoes is essential. The balance of advantage appears to be in favor of the contracting-band brake, especially when the travel is over hard-surface roads. The requirements of braking materials are that the drum be as hard as is commercially possible and retain its hardness when heated, while the brake-lining should be close-grained and hard with a uniform coefficient of friction throughout its life.—[Printed in the November, 1923, issue of THE JOURNAL.]

THE DISCUSSION

H. M. CRANE:—The two drawings shown in Figs. 2 and 3 happen to be band brakes and external. I am showing them simply to give an idea of how the principles outlined in the paper appear in actual practice. Fig. 2 is the rear-wheel brake on a semi-Hotchkiss-drive car, having a distance-rod axle control, such as I have described in a previous paper[2], and shows the point of attaching the distance-rod; also the axle center and the brake-operating linkage.

Some idea may be obtained from the length of the lever as to the amount of motion in the operating rod. The angular motion of the lever is very great comparatively, being 5 or 6 in. probably in the total travel of the brake. It is always the same; it is set in the original adjustment of the brake and is never changed. The entire adjustment for the wear of the brakes throughout their life is obtained at the brake-band. None of these other links is ever altered after the brake has been originally set. It is purely a factory adjustment. In this particular brake a toggle arrangement is used so that the first motion of the bands is relatively rapid and as the lever moves the leverage increases very rapidly.

The anchorage is not shown clearly in the figure but it is very close to the band, as close as it can be brought, with sharp, square corners, to obviate any possibility of the band's cocking under. The anchorage also is very wide compared to that frequently used on brakes of this type.

The cross-shaft, which is operating in mud and dirt

[1] M.S.A.E.—Technical assistant to the president, General Motors Corporation, New York City.

[2] See THE JOURNAL, June, 1922, p. 457.

most of the time, is provided with bushings at the two ends and a large area in the middle, which is filled with lubricant and will keep the system in working order for some time. It is absolutely essential to do this because the owners do not seem to follow up this lubrication.

Fig. 3 is a transmission brake, in which the point of interest is the link-type anchorage; you will also see that it has a nearly tangential pull on the brake-band, with a view to making sure that there shall be no cocking and no tendency to jam under the anchorage or to be self-tightening.

The operating lever and the pull-rod are also very close to tangential. In Fig. 3 they are almost exactly so. The brake shown in Fig. 2 is very close to it and because of the fact that in operation the lever swings out, it tends, if anything, to unload slightly rather than to tighten up at this point.

The points of the band are carried beyond the pivot points sufficiently far to equalize the pressure on the extreme ends. There was only one actual service-adjustment on this brake, the nut that draws the points together. There is no adjustment from the pedal to the points.

In the preliminary adjustment in the factory a set-screw is used that carries the weight of the brake-band and the overhanging linkage; and when once set it rarely needs to be changed. The other adjustment is the back-stop screw at the anchorage that provides the original clearance at this point. The clearance is maintained by a spring when the brake is released.

Lubricated Transmission

This transmission brake might easily be mistaken for a rear-wheel brake. The two drums are 12 in. in diameter and 2 in. wide. It is useless to expect to get results from a transmission brake that are not possible unless nearly the same braking area is provided as that used on rear-wheel brakes. There is no magic in the fact that the brake-drum moves faster to improve conditions as to heating and the like. The unit pressures are lower, or can be lower, on account of the higher speed, but that will not compensate for making the parts so small that overheating occurs.

I had a brake-band linking removed from a brake of a design somewhat similar to this. It was an earlier design and not so complete or so good as this design in some ways; but it is interesting as showing that it is possible to obtain practically uniform braking over the complete surface of a brake-band and thereby obtain long life.

It is also interesting in showing one of the advantages of a propeller-shaft brake; and that is the relative immunity from dirt and mud. The band has not been cleaned in any way since it was removed from the car. The car with this band on it went out of the body-builder's shop in January, 1917. The band was removed from the car in October, 1923. During that period the car had been driven 65,000 miles, mostly on the north shore of Long Island, with occasional trips up into the Berkshires and other trips of that character. It had not been driven much at very high speed and in all cases the engine was used for braking, so far as it would brake on high gear. I do not recollect that the engine was ever used on a lower gear to obtain braking effect.

In other words, the use was such as the average man would give a brake when driving in average crowded districts. The brake has, however, been run in oil, not submerged, but oiled from time to time as the condition of the lining will show. I am willing to acknowledge that this was accidental, at first. I had never seen a transmission brake in which oil did not seem to get out of the transmission and onto the brake-drums. When first we produced one we decided that the only safe thing to do was to make it so that it would hold anyway. As a matter of fact, the service was so much smoother when the brake had oil on it, for a certain amount of oil is necessary to get the full smoothness of operation, that we continued to oil the brake. We found the very desirable further result that the oil kept the binder in good condition in the lining and that the lining practically never wore-out.

This band was removed entirely by mistake. The lining has not worn-down nearly to the rivets at any point. Personally I should have continued it in service probably for 50,000 miles longer.

A. L. Riker:—Mr. Crane's statements bear out a great many experiments that I have conducted and his lubrication proposition is right. In our old chain-drive cars we used to lubricate the brake-shoes even when we used

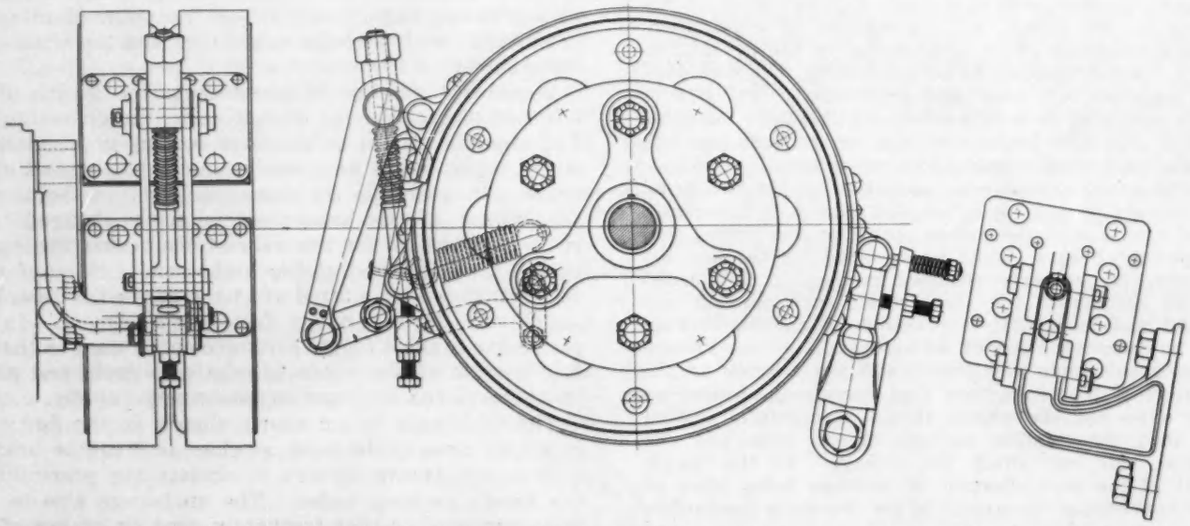

Fig. 2—Assembly of a Rear-Wheel Brake on a Semi-Hotchkiss Drive Car Having Distance-Rod Axle Control

The Points of the Band Are Carried beyond the Pivot Points Far Enough To Equalize the Pressure on the Extreme Ends and the Only Service Adjustment Necessary Is the Nut That Draws the Points Together

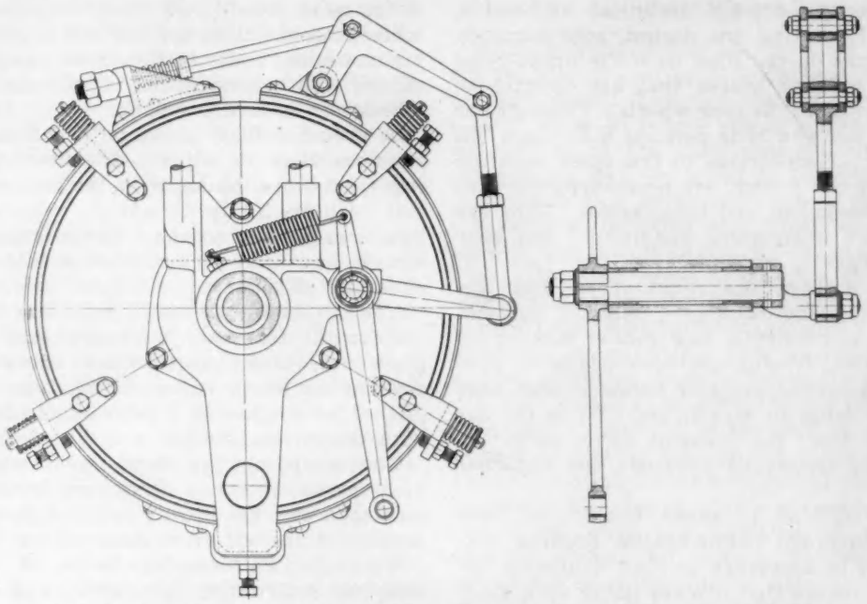

FIG. 3—ASSEMBLY OF A HAND-OPERATED EXTERNAL-BAND TRANSMISSION BRAKE
The Special Features of This Brake Are the Link-Type Anchorage and the Use of an Almost Tangential Pull on the Brake-Band To Overcome Any Tendency to Cocking, Jamming under the Anchorage or Self-Tightening

cast-iron, because we found we got a better and smoother braking action and one that is fully as effective.

DESIGN FUNDAMENTALS

A. L. CLAYDEN:—Mr. Crane has brought out splendidly the fundamental importance in brake designs, as in most other things, of designing them right and making them right. He makes it clear that the first thing a brake has to do is to absorb energy, that the durability of the brake in absorbing that energy is dependent on the amount of service it has, and that the effort that is required will depend on the amount of lost motion and friction in the operating mechanism and, of course, on the coefficient of friction. These are absolutely the fundamentals of a brake. You can get infinitely better results out of thoroughly well-made brakes of simple design than out of the most complicated mechanisms of poor construction. I believe that we have a tendency in America toward making rather complicated mechanisms, using the manufacturing standards to which we have been accustomed rather than improving the methods of manufacture.

There is no magic in having 2 brakes, or 4, or 12. You can apply any number of brakes to a machine at any number of points. Their efficiency will depend on the perfection of the work that is put into them. There is no magic about where you take hold of a thing to stop it. The idea that brakes on all four wheels have better durability than brakes on two wheels is explained by the greater braking area and the larger amount of material that is used. I think it is desirable when a discussion of a subject of this sort comes up not to speak or think quickly, but to stop and go back to the fundamental principles of what we are trying to do; in other words, of absorbing and changing a certain amount of mechanical power.

CHAIRMAN CORNELIUS T. MYERS:—Those are very pertinent remarks. I think that the development and the very extreme advocacy of some companies on the question of four-wheel brakes today will have a most salutary effect upon the usual type of brake equipment of American cars. Knight could get no recognition for his engine in this Country. He went abroad and there demonstrated to the Daimler Co., in particular, that his engine was more silent than its engine, but particularly that his engine for a given displacement would develop more power. That was a very important thing abroad where they had a horsepower tax, and it appealed particularly to the British engineering fraternity. They accepted his engine there and paid him a large royalty. He came back to this Country with the prestige gained abroad and he immediately began to get licensees here.

What happened? The poppet-valve engine builders had to sit up and take notice. Here was an engine that would produce more torque per cubic inch than theirs, and it was only about a year and a half before the poppet-valve engines had increased their efficiency to such an extent that they could exceed the power per cubic inch delivered by the Knight engine.

Now the four-wheel-brake question will certainly come up and be aired in the industry. I just want you to bear that in mind. Up to the present time brakes have been really one of the weak points of our cars. We have had some companies with the initiative to put on four-wheel brakes with the additional complications, the additional weight and the additional experience that they involve. These are not things to be considered lightly, either. I have no doubt whatever that the types of brake in common use today will be improved to an extent that will greatly surprise many people.

Another thing about Mr. Crane's paper appeals strongly to me. That is, that he did not use the so-called word "decelerate" that many men, who ought to know better, have continuously perpetrated upon us in the past year or so. There is no such word in the English language as "deceleration" or "decelerate." "Retardation" is the accepted term both in general conversation and in technical use. There are more words in the English language than any of us can use or define, and many that are constantly abused. In the interest of simplification and standardization let us be very careful how we introduce another, especially where it is synony-

mous with an already accepted technical expression.

A. M. YOCOM[3]:—Excepting one design, approximately 98 per cent of all cars on the road have the brake-pedal connected by long rods to brakes that act directly on drums, which are bolted to the rear wheels. These drums are about 4½ ft. apart and it is perhaps 6 ft. from the pedal to the drums. Connections to the three separate units, one pedal and two drums, are necessarily flexible; their bearings are inefficient and inaccessible. They are exposed to the most undesirable conditions, and they detract from clean chassis design.

Heavy retractor springs are required to keep the brakes from dragging and rattling. When it becomes necessary to make adjustments, this means jacking up the car, getting under, freeing the turnbuckles of mud and rust and setting-up the shoes or bands so that they apparently grip the same on each drum. When the car is let down to the floor, the unequal spring-deflection under varying loads completely destroys the apparent equalization.

It would be very difficult to create worse conditions than now exist in average motor-vehicle braking systems. It will always be necessary to place drums on the rear wheels, for the reason that if a car going up a steep grade should break the drive-shaft or the axle-shaft or shear a hub-key, a transmission brake would be useless. The hand or emergency brake connected to the drums on the rear wheels is the proper arrangement to meet such conditions. The layout, of course, must be made so that loading and unloading do not affect the brakes.

A brake on the drive-shaft immediately behind the transmission is being designed. The adjustment is easily accessible to the driver as he is piloting his car down the street. As he screws down on the thumb-nut, he can easily feel a tug if the bands or shoes begin to drag.

The foot-pressure required to stop the car is less by several hundred per cent, assuming equal braking areas, than that required when the bands or shoes make contact with rear-wheel drums. The commercial linings that are now marketed have frictional qualities that are wholly adequate. It is not improbable that the contacting surfaces can be made of metal that will last the life of the car. Connections from the pedal to such a brake are short and positive. The mechanism could be easily shielded from foreign matter that would cut the drums, air-scoops could be arranged in the shield, and several streams of air poured directly on the parts that might become heated.

The slight addition, which might be necessary in making the rear axle strong enough to withstand the additional braking strains, would be more than offset by the removal of one set of brakes on the rear axle; and the neat appearance, which is gained, is another factor to be favorably considered.

Let us assume that a man steps into his car. The service brakes are on the two rear wheels. The man drives down the street, comes to a cross-road, and attempts to stop his car. The car retards only slightly. He does this every morning and throughout the day, perhaps for the next 30 days, each time promising himself that he will have his brakes adjusted. If there were an accessible thumb-nut at his feet, that would adjust the permanently equalized brakes, would he drive for 30 days without brakes?

Front-wheel brakes, the latest necessary arrival in the automobile industry, perform remarkably well when hooked-up to a transmission brake. This arrangement is far more satisfactory than connecting them with rear-wheel brakes. It means one rod 3 to 5 ft. long from the transmission brake to the front axle, as against 20 ft. of rod and several brake countershafts when the four wheels are hooked together.

A propeller-shaft brake with a thumb-nut adjustment requires 30 sec. to adjust. The latest type of self-equalizing front-wheel brake, with the lateral sliding operating rod, requires 2 min. to adjust. The latter arrangement can be easily connected so that it is possible to slide four wheels, or it may be arranged so that it is impossible to slide any of them.

The latest safety coach is built very low. To get brake-rods to the rear axle is an additional problem. To get good four-wheel brakes without excessive pedal or servo systems on heavy motor-vehicles can be readily accomplished by the use of a drive-shaft brake in conjunction with front-wheel brakes.

The wrapping-type band-brake requires little pedal pressure but seems at times very harsh. The non-wrapping type with the many retractor springs requires heavy pedal-pressure but gives good positive action.

With the transmission brake of the non-wrapping type the retardation is positive and free from all the harshness that makes the action of the wrapping-type brake at times very uncertain.

R. W. A. BREWER:—Mr. Crane has mentioned that the mechanism of braking is practically the same as it has been for the last 15 years. The difficulty in applying the mechanism is, I think, in getting a frictional surface that can be relied on; the light that he threw upon it when he showed us the lubricated fabric brake-lining seems to indicate that if we could modify our brake designs so as to use existing types of fabric and to give the fabric under working conditions some kind of uniform lubrication, we might get over what seems to be the greatest difficulty of the brake problem at the present time.

Mr. Crane referred to the fact, of which we all know, that the ordinary type of woven fabric varies enormously from time to time in its braking effect. It is apparently of little use to elaborate on the application of the pressure if the result when the pressure has been applied does not remain within some reasonable measure of uniformity.

There is one other point that nobody seems to refer to, except in the very casual way of saying that such and such a brake can be adjusted in 15 sec. and another one in 2 min. Under actual service conditions, the great difficulty of making an adjustment is the bugbear. If one could design adjusting screws, springs and the other mechanisms that hold surfaces in contact or withdraw them, so that the adjustments could be made and so that the various springs would function, I think we should have people more anxious and willing to make adjustments.

EFFECT OF AXLE MOVEMENT ON BRAKES

C. J. EVERETT:—Many designers of brakes either do not understand kinematics or, if they do, pay little attention to the relative movement of the brake levers as influenced by the movement of springs and the rear axle. One car-builder admitted that on its late models a great amount of trouble is encountered because the brakes become set by the partial rotation of the rear axle when going uphill and released by the same action when going downhill. This results in the burning-out of the brakes going uphill and prevents their gripping when going down.

[3] M.S.A.E.—Chief engineer, U. S. Axle Co., Pottstown, Pa.

In the service-stations they set the brakes as loose as possible and trust to luck that they will hold on a hill. This make of car is not the only one that has this trouble. It is not a difficult matter to design a brake mechanism that will not be influenced by the movement of the springs and the rear axle. As the brakes are about the most important thing on an automobile, there is really no excuse for jeopardizing lives by defective brakes.

RALPH M. WERNER:—Regarding the question of axle displacement in Hotchkiss-drive type of vehicle, due to the driving and the braking reactions and the effect of such displacement on the action of the braking system, let us assume that the wheel is turning; we apply the brake to the wheel; naturally the brake tends to turn with the wheel and the axle with it. The result is that the axle displaces itself in a direction corresponding to the wheel rotation and in doing so changes its relation to the brake-operating linkage so as partly to release the brake that has been applied. On the other hand, it is well appreciated that an axle in driving tends to displace itself in a direction opposite to that of the wheel rotation, and with the standing type of lever for brake operation, this results in the brakes applying themselves to some degree. In service, when the brakes were closely set and the wheels rotated freely when jacked up, I have seen the same brakes apply themselves to such a degree, due to driving-torque reaction, as to cause them to heat. The same brakes when applied were none too good. In my opinion, it is highly desirable to mount brake-levers on axles in a hanging manner, which will produce the reverse effect on brake performance to that of levers of the standing type, as described above.

HERBERT CHASE:—I assume that Mr. Crane's paper applies primarily to ordinary passenger-car construction, but also to other types of vehicle. Has he considered the possibility of using the same general type of device that is used in railroad practice, namely, a slack-adjuster, which takes up wear and keeps the brakes in proper adjustment? Provided a sufficiently simple mechanism could be devised, some such scheme might be desirable in the case of brakes that tend to wear rapidly.

Mr. Crane, rightly, I think, favors the use of the engine as a brake, especially when driving in hilly country but, unfortunately, there are many unskilled drivers who do not appreciate the value of the engine as a brake, or, if they do, attempt to change gears and use it after they have started down a grade, when it may be too late. This suggests the desirability of providing some sort of gearset that will facilitate changing down without clashing gears. One of the new cars has such an arrangement, which, it seems to me, merits attention by other builders.

Some interesting designs of air-operated brakes were exhibited at the recent Motorbus Show in Atlantic City; and some bus designers are inclined to believe that air-brakes will be applied to bus and perhaps also to truck service, and possibly in some cases even to passenger-car service.

In at least one installation of air-brake, metal-to-metal shoes, which it is stated are mild steel to mild steel, are employed with considerable success. This is said to avoid rapid wear under severe braking conditions in which ordinary linings wear rapidly, much less frequent replacement being necessary. The tendency is to keep away from such unnecessary complication as is apt to be involved in an air-operated brake. This type of brake has some advantage with respect to ease of application.

FOUR-WHEEL BRAKES

HAROLD NUTT:—The real problem in brake design is not so much to do away with heat dissipation on long gradual slopes, or to stop the car as we should like best to stop it, as to reduce the appalling accident rate that we read of in the daily papers. Approximately three persons per day are killed in New York City alone. It is probable that an average car in good adjustment has a braking system that will allow the locking of the rear wheels; and that is all one can get with two-wheel brakes. I advocate four-wheel brakes for the reason that they enable a car to be stopped in about one-half the distance required by two-wheel brakes, and are, therefore, safeguarding human life. This is something that should receive attention from a humanitarian standpoint.

C. M. MANLY:—It seems to me that the most important point to consider in the matter of four-wheel brakes is that of getting hold of the energy to absorb it. Mr. Crane and some others have stated that the brake is there to absorb the energy of the car and, except for certain conditions when the question of providing sufficient braking surface for heavily weighted cars on a single set of wheels comes in, the important question with the passenger car is to get hold of this energy of the car so as to absorb it when the streets are slippery. That is largely the criterion as to whether we need four-wheel brakes. If somebody can show us how to keep two wheels rolling so that they will not slip, we shall know that we can absorb all the energy that the ordinary passenger-car has with two brakes on two wheels; but if we cannot get all the energy out of the car quickly enough without danger of slipping those two wheels, we need more points of contact to get hold of more of the energy and absorb it more quickly.

CHAIRMAN MYERS:—That is a mighty good point to take home with you, no matter on which side of the question you stand. I shall quote from a short letter that A. R. Erskine, president of the Studebaker Corporation of America, wrote. He was invited to come or send someone, as were the officials and engineers of a number of other prominent automobile companies. He says:

> I do not care to get into a discussion with an engineer on four-wheel brakes. I am not an engineer; I decide matters of design from the standpoint of commercial practicability rather than from an engineering standpoint.
>
> The six disadvantages of four-wheel brakes, from a commercial standpoint, are set forth in our advertisement, and you are at liberty to quote me accordingly.
>
> Those six points are
>
> (1) Danger of accidents, due to misadjustment or misuse
> (2) More adjustments by owner
> (3) Added impediments and lubrication points
> (4) Decreased car-efficiency
> (5) Harder steering and control
> (6) Greater expense of maintenance

MR. CRANE:—I wish to thank Captain Brewer for again urging the necessity for easy brake adjustment. The car-owner rightly resents spending as much time tinkering with his car as in driving it; or, to put it another way, the average owner would rather enjoy the car by using it than by filling inaccessible grease-cups or trying to adjust impossible non-adjustable brakes.

Regarding that brake-band, I ought to add that it was operated on a chilled cast-iron drum, which, as you know, begins by being very hard and ends by being very hard.

It is not affected noticeably by any heat of braking, which of course has added immensely to the life of the lining.

Regarding axle variation, in the Hotchkiss drive the master-leaf of the spring is usually underslung; the brake hanging is operated by a lever pivoted on the brake disc; the disc at the end of the axle is permanently attached to the axle; the brake-operating link is practically in line and parallel with the master-leaf of the spring. With such a layout, the contortions, which are taken up by the axle with a Hotchkiss drive on rough roads and under heavy braking conditions, practically have no effect on the hand-lever that is used. It can be held readily in the hand or can be locked in the quadrant. That is the real test of a suitable brake-linkage. If you can lock the lever in the quadrant and not have the wheels jump and bump, with the brake holding one minute and releasing the next, you will have the real answer as to whether the brake-linkage is right. The linkage shown in Fig. 2 is 100-per cent that way. The brake-lever when held in the hand over the roughest kind of road has no reaction against the hand, except the straight pull of the braking itself and of the retractor springs. There is no jumping of the hand-lever whatever.

Mr. Chase raised the question of brake-slack adjusters. These are commonly used in railroad practice at the present time. Railroad-brake designers of some years ago did not know any more about them than some of us have known about our brake design, as is evidenced by what happened on the Hudson & Manhattan Railroad when the first lot of cars were put into service. They were equipped with brake-slack adjuster that worked in one direction only. They took up the slack but did not release again if conditions required it. These cars would take a heavy load of passengers from the Hudson Terminal to Newark and the springs would settle accordingly; on the return trip the brakes would drag. In other words, the linkage was designed so that when the springs were depressed, the brakes were released and the slack-adjuster would operate properly; when the load was removed, the brakes were pulled up against the wheels.

I am afraid that a slack-adjuster of the automatic type, in connection with foot linkage or hand-operated linkage on a car, would be too trappy to use. I cannot see the need of it, because I know that, by proper design, simple readily accessible adjustment can be provided, and, moreover, that if the brake design is correct to begin with, the area sufficient and the parts rigid, the adjusting of brakes in ordinary service is very rare. The transmission brake referred to above has been in use for between 15,000 and 16,000 miles. The total adjustment has consisted of 1½ turns of the adjusting screw that may be seen in the illustration; three different adjustments of a half-turn each at intervals of about 5000 miles.

QUESTION:—With the throttle closed, what increased braking effect of the engine is obtained by shuting off the ignition?

MR. CRANE:—When I say throttle closed, I really mean it; I do not mean with the engine throttled down to 500 or 600 r.p.m. If the throttle really is closed, sufficient mixture is not taken into the cylinders to fire and, therefore, the ignition may be left on as well as not. That is the usual way in which I drive a car; there is no evidence that the engine is developing any power whatever under those circumstances.

QUESTION:—How can muffler back-firing be prevented under these conditions?

MR. CRANE:—Occasionally, with certain types of carbureter adjustment, back-firing will be heard in the muffler, but I find that, if the carbureter adjustment is approximately correct, back-firing never occurs in practice.

QUESTION:—What material should be used for band-brakes?

MR. CRANE:—That is largely a question of how good a brake it is desired to produce, or how large a brake can be used to get the desired results. The cheapest form of drum is the drawn-steel drum. If it is not too wide in relation to its diameter and the thickness of metal, it will be satisfactory for reasonably severe operation; but it is usually of too soft material to be of the best service. The lining that I know the most about is a straight asbestos-fabric lining with woven wire. With band-brakes I believe it is entirely satisfactory. I believe it is not possible to use molded lining satisfactorily with a band type of brake. With a shoe brake it is undoubtedly excellent for the purpose.

QUESTION:—What relation has the thickness of the drum to its diameter?

MR. CRANE:—This, again, is a matter of compromising. With the band-brake, however, distortion of the drum under the braking effect is of minor consequence. A well-designed band-brake can operate with a very flexible drum; that is, I think a 2 x 12-in. drum, 3/16 in. thick, can be used. I would not advise it. I think ¼ in. would be better, but even the 3/16-in. drum would operate satisfactorily. It would not, however, take up heat rapidly during short applications, or take up as much during short applications as a heavier drum. On long applications, it would release the heat as fast as the heavier drum and, therefore, be equally good.

QUESTION:—Do you recommend oiling brake-bands as a regular practice?

MR. CRANE:—On transmission brakes or brakes that are entirely protected from dirt, if the operating conditions permit, I think oiling is a very good thing; it is necessary, however, to have a powerful leverage to offset the lower coefficient of friction of a lubricated brake.

I remember very well the late Mr. Hartford's demonstrating his electric brake to us some years ago. He found that when he had an electric brake with practically infinite power he got much better results with lubricated bands. He used the bands on the rear wheels.

QUESTION:—What was the probable maximum torque exerted by the transmission, the brake-lining of which you showed?

MR. CRANE:—The car weighed, without passengers, 5500 lb. It was equipped with 35 x 5-in. nominal-size cord tires, measuring about 37 in., and had a rear-axle gear-ratio of 3.2 to 1. The brake-drum diameter was 10½ in. The brake could readily slip the rear wheels, when occasion required, on a dry concrete or an asphalt road. This was required often as the car was driven in New York City traffic and in crowded surburban districts. That type of service, however, is not hard on a properly designed brake. A quick stop from 20 or 25 m.p.h. on a brake of sufficient area is not likely to cause serious wear. It is the long pull on a heavy downgrade or retardation from very high speed that causes wear, on account of both the work required and the attendant high temperature.

QUESTION:—Is it not true that, in the use of an engine as a brake, compression does not assist retardation, owing to the fact that the energy absorbed in compression is returned on the following expansion-stroke?

MR. CRANE:—That is true to a large extent. The two greatest forces in the engine-braking effect are the engine friction, and the pumping loss due to pumping against the suction in the manifold. That is why the engine shows a higher braking efficiency with the throttle closed than with the throttle open.

QUESTION:—Why is the outer front-wheel always released when making a turn with front-wheel brakes?

MR. CRANE:—I understand that the hydraulic brake applies equally on both front-wheels regardless of whether the car is turning a corner; and many of the mechanical brakes also do so. The idea of releasing the brake on the outer front-wheel while making a turn is, of course, to improve the steering conditions.

QUESTION:—What is the peripheral speed at which the coefficient of friction is the maximum?

MR. CRANE:—There is undoubtedly a variation in the coefficient of friction at different speeds. I do not know exactly what it is. As a rule the friction of rest is higher than the friction of motion.

QUESTION:—Why are metal-to-metal brakes not used more?

MR. CRANE:—I think that question is partly answered by the rear-wheel brake situation. It is difficult to get a metal-to-metal brake with a coefficient of friction high enough to operate with the pressure that is obtainable on a rear-wheel brake. We used metal-to-metal transmission brakes at first, having a shoe-type brake with a hardened drum. The results were satisfactory so long as the temperatures were kept within reason. If the temperatures were allowed to run too high, the brake surface would begin to scour and very rapid wearing of the brake-shoe material would follow. The brake-shoe material we used at that time is of interest today, as it is practically the same material that is now being used for very high-duty engine-bearings. It was a bronze, having a very high proportion of lead in its composition, upward of 50 per cent. It was called plastic bronze. The difficulty, of course, with such compositions is the maintaining of any real mixture of the two. The lead tends to separate in molding but the metal has the property of operating dry on steel surfaces with practically no tendency to pick up, unless the pressures are extremely high or the heat excessive.

QUESTION:—What is the effect on the effectiveness of braking of oiling the brake-lining of rear-wheel brakes of average size?

MR. CRANE:—There are many car-owners who could answer this question as well as I can, unintentionally. The trouble is that the oiling does not seem to be the same on both rear wheels. There are two difficulties in using oil on rear-wheel brakes. One is that of dirt, the accumulation of dust caught in the oil. The other is the getting of sufficient pressure to operate at the low coefficient of friction available with an oiled brake.

QUESTION:—Is it better to use engine oil or neatsfoot oil?

MR. CRANE:—We have never tried the latter. What we ordinarily used was gear-box oil or steam-cylinder oil, the 600-W type.

QUESTION:—What is the present status of automatic brake adjustment?

MR. CRANE:—So far as I know, it has no standing at all, at least in this Country. I do not know of any cases abroad where automatic adjustment is used on commercial passenger-cars or trucks. It should not be necessary if the brakes are properly designed.

QUESTION:—What steel is best for the drum?

MR. CRANE:—There is no question that the harder the steel is the better, especially steel that will retain its hardness at high temperatures. This can be obtained in ordinary machine-steel by running the carbon-content as high as the design will allow. If a forged drum is used, the carbon-content may be very high. If a drawn drum is used, the carbon-content probably will have to be lower, but the higher it is the better, within limits; probably 60 or 70-point, or even 90-point, might be worth using. As a matter of fact, a chilled cast-iron drum is excellent. A manganese-steel drum also is excellent but commercially impractical because of the fact that it must be produced by casting and when ground and balanced is excessively expensive.

QUESTION:—Why has the disc-type brake no possibilities?

MR. CRANE:—To answer that question I should have to go into a great many questions of practical design. What I meant to say in the paper is that the disc-type brake apparently has shown no possibilities. It has been proposed from time to time and some rather meritorious designs have been worked out. Its failure has been due, I think, to the difficulty of properly releasing a disc-type brake. With sufficient area of braking surface the single disc might be all right, but a multiple-disc brake is very hard to release completely in any reasonable space; and the space available in motor-car design is very limited.

QUESTION:—What is the maximum retardation in feet per second per second for comfort in heavy passenger-cars, and should this be uniform during stopping?

MR. CRANE:—W. S. James, of the Bureau of Standards, has found that the average passenger-car on a dry road, braking on two wheels with full efficiency, which happens to coincide with slipping the wheels, produces a retardation at the rate of about 13 ft. per sec. per sec.; braking on all four wheels, the retardation is at the rate of about 25 ft. per sec. per sec. My feeling is that in commercial service even this lower rate would be rather uncomfortable to passengers; in other words, if the brakes were applied on a passenger-car when the passengers were not expecting it, they probably would be thrown out of their seats.

With regard to the second part of the question, it has proved to be desirable in railroad service to release the brakes partly before coming to a dead stop. I think the same thing should hold true in motor-car transportation to produce the smoothest possible stop.

QUESTION:—Is the four-wheel-brake idea a sales rather than an engineering achievement?

MR. CRANE:—I should say that a good four-wheel brake is an engineering achievement. There are some good ones in the United States at the present time.

How Engineers Can Cooperate to Make Flat-Rate Service a Success

By J. Willard Lord[1]

Dayton Service Meeting Paper

ENGINEERING and maintenance should go hand in hand. Engineers and service-men are too little acquainted with one another's problems, but it is more important that engineers should be familiar with the troubles of the service-man than vice versa. Flat-rate charges and time standards for maintenance work make comparisons more easy than those based on the old system of charging for labor by the hour; they should represent real value received and not include the cost of inefficiency and of excessive amounts of material. They furnish an incentive for producing special tools and equipment for making repairs come within the time limit and reducing their cost. The custom for each shop to work out its own salvation leads to needless waste. A factory service paper describing the latest shop kinks would disseminate new ideas and lead to more coordinated effort; service conventions at factories, to stress the matter of repair tools, would also be beneficial. Means of, and tools for, repair should be given consideration in designing vehicles. Accessibility of parts and facility in making replacements would reduce the time needed to make repairs. Discrimination is necessary in determining when worn parts should be replaced. Much expense can be saved by putting such parts in serviceable condition by using bushings or cheap wearing parts of other than standard sizes and by regrinding cylinders, pistons and the like. A much discussed topic is the expense of repair parts. The more directly these can be purchased the less the handling charges will be. The relatively high cost of certain parts obtained from the factory compared with those obtained outside may be laid to "overhead." The fact that some parts which give satisfactory service can be obtained more cheaply from parts manufacturers should lead factory managers to investigate the reason; it might be found to be due to the distribution of the burden or to selling methods. Distributors keep their stocks at the minimum but probably would order in larger quantities if proper incentives were offered. The rendering of decisions by service managers on parts "within guarantee" is another thing that has been tried with success and might be more generally followed to advantage.

AUTOMOBILE maintenance has become the largest branch of one of the largest industries in the world, if not the largest. In its very nature, the maintenance industry has much of an engineering and technical character and is closely related to and somewhat dependent upon design and production. Because of its size and nature, it deserves the study, interest and intense application of thought of engineers fully as much as do the present problems at the factory.

Service and maintenance establishments, large or small, are rapidly getting away from hit-or-miss methods of conducting their work. They are becoming better organized, are employing a better and more intelligent class of personnel to meet customers and to supervise the work and are conducting themselves more and more along modern, straightforward and honest business lines. Evidences of this are a general introduction of flat-rate charges for repairs, and just as important, Mr. Bachman, of the Autocar Co., believes more so, the establishment of shop standards for measuring the performance of mechanics, thus permitting either piecework compensation or some form of bonus payment. This all acts to establish far more healthy internal shop conditions, building up the morale of the men and, in turn, being reflected in better products and better pleased customers.

In other words, the maintenance industry has not stood still but has been working hard and with considerable success to get its house in order to service and maintain more effectively the cars and trucks that engineers and factory men are placing on the streets and to see that they give continuous satisfaction to customers, yours and mine, who purchase them.

I say "yours and mine" because, even though dealers and distributors may be under contract to take the factory product, we cannot realize keenly enough that we have, in the final analysis, one and the same customer, namely, the car or the truck owner. We are very much in the same boat, but, I feel, are farther away from one another than is best, to secure, quickly and effectively, the results at which we aim and for which we strive.

Quite possibly, and in all probability, we in the maintenance field do not understand and do not realize the many problems with which the engineers are obliged to grapple. On the other hand, we feel just as positively that the engineers really are unacquainted with our problems, even though they design and build the cars and trucks that we take care of.

Need of Cooperation

I feel that engineers and factory men, with exceptions, of course, do not really know us and our problems in the field. We do not get close enough together. The engineers are only casually acquainted with us; they pass our front door occasionally. I admit frankly we do not know their problems. At the same time, for the benefit of the industry, it is really far more important that they know our problems than that we know theirs.

Mr. Kettering wrote, not very long ago, that engineers should be more like business men. He was asking engineers to broaden their interests and to look at the engineering of motor vehicles from other standpoints than just that of design.

Service and maintenance, more definitely the actual making of repairs, is a big engineering problem and one affected by design and production. I think it is a problem that, when the engineering has been coordinated, starting with design, is bound to lead to a production of vehicles that will give greater satisfaction to the buying public than ever will be possible under the general conditions of largely disassociated engineering effort that exist today.

Meetings of this kind, bringing service-men and engineers together, are a decided step in the right direction and I hope that the interest aroused by gatherings

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of this character will lead engineers to organize and arrange their work so that they can feel free to get away from the factories and into the field for real "get-acquainted" visits, so that they can actually see, first-hand, what their product is doing in service; what its faults are and just how they develop; where changes in design would greatly improve accessibility, facilitate repairs and the use of standard tools, rather than shop-made special affairs that are invariably expensive and sometimes of doubtful value.

Maintenance price-competition is by no means something new. However, flat-rate charges make comparisons more easy than ever before. Therefore, it is more important, from the standpoint of cutting down sales resistance, that maintenance charges represent real value received and not include the cost of much inefficiency and excessive material charges.

Shop standards and flat-rate charges are bringing to light and making us realize fully many valuable lessons and ways and means to reduce maintenance charges. Perhaps the most interesting lesson is the value of having the right tools for every job readily available and an incentive to use them. This results in surprising reductions in the time necessary to perform a repair operation. Tools, however, are not everything; we must develop the best method and establish a reward or incentive for doing the work within the time set and in the manner we wish it done. This is no more than we are doing every day in our factories on production work.

I am certain that along with the adoption of flat-rate charges more money than ever before is being invested in repair tools. When labor is sold by the hour little incentive to develop or purchase tools exists, because the tool cost increases the overhead and the whole advantage obtained immediately goes to the customer. Not so with the flat rate. Once the selling price has been set, every incentive to invest in tools and other equipment that will cut the cost of the job is present. The savings effected not only take care of the increased overhead but go to make a real labor-profit.

Development of Special Tools

As to the development of these tools, aside from tools purchased in the open market, almost every shop is working out its own salvation according to the ideas of its foremen. There is almost no coordinated effort. This means slow accomplishment and needlessly heavy expense. Some of these tools are most clever and simple in design and operation but the idea back of them is buried in the particular shop in which they were made. Others are altogether the reverse but are better than no tools at all. Would it not pay to establish a factory service paper, or include a tool and equipment section in a factory house-organ, and offer some nominal compensation for designs of tools made and in successful use and a prize for the best design for performing any given operation? This would dig out good tools that are hidden away.

Would it not pay to consider tools for repair at the time of designing the vehicle, when the addition of a lug here or a hole there would permit the use of a simple repair-tool rather than a special complex affair made necessary because repair tools have not been considered?

Would it not pay to hold service conventions at the factories from time to time and stress the matter of repair tools? I believe that from coordinated effort of this kind would come a better tool development and at a considerably less cost. Factories have done something in the way of designing and making up service tools in quantities, thus cutting down the cost. I should like to see much more of this, though in working out the design, what has been done in the field, where necessity has been the mother of invention, should be viewed. Again, in making up these tools, consider that they will not receive the hard continuous wear-and-tear of production tools and that many corners can be cut in reducing their cost.

It is almost needless to state that the degree of accessibility has much to do with the extent of labor charges for a given job, irrespective of good tool development. If a vehicle must be partly dismantled to make some simple repair, it will take time to perform this labor. Another phase of accessibility relates to the ease and facility with which major and minor units can be removed and replaced. This applies more to trucks than to cars. Unit exchange greatly reduces the days per year that a truck need be laid up for repairs. As truck operators learn more and more how best to use their equipment, they are operating their trucks a greater percentage of the time and are charging to maintenance the rental of trucks hired temporarily while their own vehicles are undergoing repairs. Greater accessibility and ease of removing and replacing units will do much to help cut down flat-rate charges.

Reduction of Parts Expense

Aside from getting maintenance expense down to rock-bottom through the various avenues open to reduce labor expense, another remains—that of parts expense. In the first place, considerable discrimination is required to decide when a part is worn sufficiently to require replacement. This matter is more difficult when the replacement of parts is under consideration, not because the parts no longer can give service, but because partial wear of them develops noise. One owner does not object to noise; another will not tolerate it. Many reductions in parts charges are made by putting worn parts into serviceable condition. Much of this class of work depends on using bushings and other comparatively cheap wearing parts of other than standard sizes. We regrind cylinders, use oversize pistons and oversize piston-pins, regrind crankshafts, and the like. This is standard practice because these parts are of considerable value. The same idea can be carried out in the case of much smaller parts, but general practice in this respect is essential to warrant the production of the necessary undersize bushings and the like. The men at the factories can do much to make such practice standard.

Price of Repair Parts

Repair-parts price has been and is a topic for much discussion, even in the comic sections of the newspapers. Jeff, of the famous team of Mutt and Jeff, at one time marketed a car at a figure so low that Mutt could not see wherein the profit lay. Jeff replied, "There is none. But wait till the poor suckers have to buy parts." This sort of thing does much to mold public opinion. It is not a laughing matter. The parts manufacturer selling direct to customers also is doing much to mold public opinion.

A sharp line should be drawn between finished commercial parts purchased outside the factories and the parts produced and finished within the plants. As to commercial parts, these, as finished articles, in many cases go through more hands than seems necessary, though the number of exceptions is increasing. Grease-cups and ball bearings were among the first articles for dealers and individual owners to purchase locally. It

stands to reason that the more directly all these parts can be purchased, the less the handling charges will be. This should result in lower prices to owners.

The argument has been advanced that it takes a factory inspection-department to protect dealers from unscrupulous parts manufacturers or from the parts manufacturers from whom the factory is buying. On the other hand, if these persons are looking for a greater outlet for their products they must give service to retain any new business they may secure. Furthermore, I think the average parts manufacturer has as much pride in his product as has the average automobile builder.

Direct Selling of Parts

Direct selling of automobile parts would help to reduce the factory parts-inventory. Let parts manufacturers selling to factories sell direct where quantity orders are of such size as to interest them. If factory tools are used in the filling of such orders, the respective factories should receive royalty payments accordingly.

We are told that the factory overhead is one of the principal reasons for the high cost of certain parts compared with outside prices. Whatever may be the reason, many repair-parts that can be obtained far more cheaply from parts manufacturers give such service as to make them compare favorably with the factory product. This being so, do not the production of parts and the pricing of them deserve attention? If your production costs are right, what about the distribution of the burden? If you have a heavy investment charge, would it not pay to adopt the selling methods of these parts-makers and offer discounts for quantity purchases and time deliveries? This would allow you to reduce your inventory and tend to spread it over the stocks of your distributors. I think it would lead to lower prices of the parts most consumed, which is a thing most needed.

As it stands today, every distributor keeps his stock at the very minimum at which he can operate; sometimes below this figure. The manufacturer is obliged to keep up his stock for the whole Country. Both distributor and factory are at a decided disadvantage because of this condition. The distributor is at a disadvantage in carrying so little stock. His customers encounter shortage much too often. Ordering small quantities frequently, receiving small quantities frequently and keeping the records involved, require a great amount of clerical work. The cumulative effect of small orders and shipments concentrates at the factory and must make parts department overhead much higher than it would be if parts were ordered in larger quantities. Clerical, stockroom and shipping charges are bound to be higher per unit. I believe that dealers would order in larger quantities if the proper incentive were provided.

One other thing would help flat-rate service and give the customer an immediate answer as to cost. Today, it is usually a factory prerogative to pass on parts "within guarantee." However, the fact that one company has been able to have its service managers in several localities render final decisions on parts within guarantee, resulting in an immediate answer so far as the customer is concerned, shows that this plan can be followed much more generally than is the case today.

WARREN G. HARDING

IT is becoming increasingly clear that the men in our public service who have the firmest grip upon the hearts of the people are those who with unfailing conviction stand for the strong and enduring things of religion. We are constantly admonished by the cynic and the pessimist that our age is marked by the decline of religion, that moral atrophy and decay are conspicuous in our social and political life and that already there are evidences of the disintegration of what we have been pleased to call "Christian civilization." We lay no claim to moral impeccability, we are sadly conscious of our deficiencies, but we refuse to believe that, at heart, the men and women of this Nation are losing their faith in Him in whose hands are the issues of life. The great leaders of our Country today are the witnesses of a living Christ. Human frailties they doubtless have, mistakes in judgment they frequently make (and who of us does not?) but more and more they openly acknowledge the sovereignty of Him who, by teaching and example, sought to lift the world to new levels of service and happiness. The better understanding of men, the finer appreciation of the hindrances and difficulties that encompass their paths, the truer Christian charity that forgets their failings and rightly appraises their virtues, will do more to restore the peace and happiness of the world than all our vaunted legislation and all our social and political nostrums. Well may we acclaim Warren G. Harding as the apostle of a better understanding. We shall cherish his memory, not as the leader of a party, but rather as the exponent of the better way, the man who with loving heart and self-sacrificing service gave to his Country the full measure of devotion and like the great Master whom he served faithfully for many years, "counted not his life dear unto himself."

Our best expression of respect and affection will disclose itself, not in words of praise but in a life of complete devotion to those ideals that alone secure to us life, liberty and the pursuit of happiness.

The whole world today is distracted and distressed because love and loyalty for the while have been displaced. No matter what our boast of material things may be, no matter what our sense of security may suggest of self-ease and self-satisfaction, we shall guarantee to ourselves and to the great world neighborhood in which we live those things that are most precious and satisfying to us, only as we in our place, be it great or small, rededicate our lives to the service of Him whose second great commandment was: "Thou shalt love thy neighbor as thyself."

Our heritage as citizens of this noble Republic is incomparably great; well may we with chastened pride boast of the men and women who through devotion and sacrifice have brought us to this day of larger privilege. But our boasting and our pride will not save us from distress and disaster within, or invasion from without, unless we build up here in our United States the enduring things of Christian character.
—James E. Freeman.

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General Design and Urban Performance of Electric Trucks

By J. G. CARROLL[1]

MID-WEST SECTION PAPER *Illustrated with* PHOTOGRAPHS AND CHARTS

CONSIDERATIONS that influence the design and location of motors suitable for use in electric trucks are first given attention and afterward the various methods by which their control is effected. Details of construction and the factors that determine the selection of the best type of drive are discussed, as are also the accepted kinds of cradle for supporting the interchangeable battery. An examination of the requirements of delivery systems operating over city routes shows that the electric truck is capable of meeting practically all demands of mileage, topographical conditions and speed. Its distinctive advantages are said to include economy, simplicity, dependability, reliability, durability, cleanliness and freedom from contaminating odors, freedom from high temperatures, ease of operation and maintenance, and minimum fire hazard. These are attributed to substantial construction and the absence of the reciprocating internal-combustion power-unit, which eliminate road troubles, reduce maintenance expense to a minimum and obviate the necessity of high-priced mechanics; to minimum vibration, freedom from adjustments and the prevention of careless and reckless speeding, which prolong its useful life; to reliability and uniform driving-power throughout the life of the motor that delivers the maximum power automatically to the driving wheels as it is required; and to operation at economical speeds on account of the inherent characteristics of the series motor that automatically decreases in speed as the load is increased.

THE scope of this paper is so broad that no attempt will be made to enter into detailed discussion. It is intended to convey a general idea of what the electric truck is and of its place as an urban transportation unit. An electric truck is simple in comparison with a gasoline-operated truck. Opinions should not be formed and conclusions hastily drawn, however, that the electric truck is merely an assemblage of frame, axles, wheels, motor, controller and transmission members into an operative unit. The detail parts require careful attention and study in order that they may be designed to assure maximum efficiency with a consequent increase of useful work from the stored energy of the battery and a decrease in the cost of operation.

The electric truck is scientifically designed to give long life in service, a property that is influenced considerably by the absence of complex motive power and control mechanism and by freedom from the numerous reciprocating parts and extreme temperature variations that are inherent in gasoline trucks. Any electric truck conforming to accepted automotive standards comprises three major members: the chassis, the battery and the body. The chassis, in general, consists of the frame, the motor, the transmission members, the springs, the axles, the wheels, the steering-gear, the control equipment and all the other units necessary for the propulsion and control of the truck.

[1] M.S.A.E.—Chief engineer, Walker Vehicle Co., Chicago.

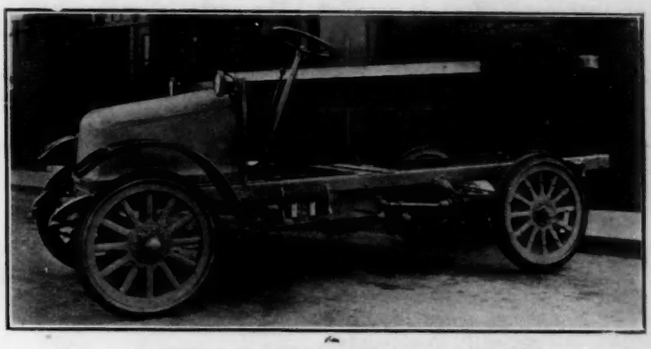


FIG. 1—TYPICAL LIGHT-DELIVERY ELECTRIC-TRUCK CHASSIS
This Design of Chassis Is Generally Used Only on Vehicles, the Load Capacity of Which Is Less Than 1 Ton

The general layout of the chassis involves principally the location of the driver's seat, the motor and the battery, inasmuch as they affect the load, the weight distribution, the overall length of the chassis and the wheelbase. Layouts of electric truck chassis may be generally classified under two types of design. In one type the driver's entrance is located back of the front wheels and part of the battery generally is mounted over the front axle under a hood, with the remainder mounted over the frame, under or back of the seat, or underslung near the middle of the frame. This type facilitates the entry and the egress of the driver but necessitates a greater overall length, which is disadvantageous from the standpoint of garage space and of handling or maneuvering in congested traffic zones. Likewise, a longer wheelbase is necessary to assure proper load distribution. A chassis, representative of this type of design, is illustrated in Fig. 1, but in general is not used to a great extent on chassis of capacities exceeding 1 ton.

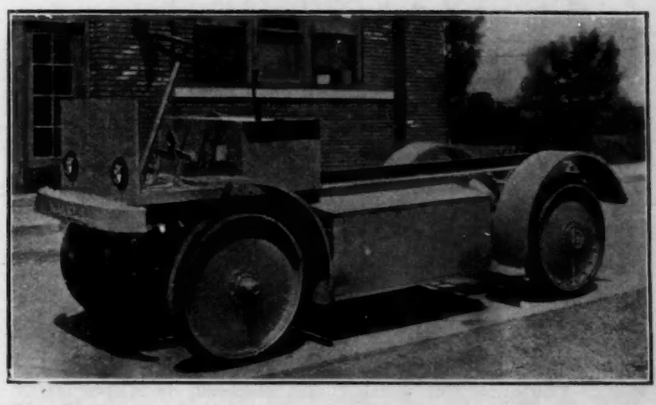


FIG. 2—CHASSIS USED ON ELECTRIC VEHICLES HAVING A CAPACITY OF 2 TONS AND OVER
In This Type the Battery Is Underslung and the Driver's Seat and the Control Mechanism Are Combined To Form a Single Unit That Is Readily Removable from the Chassis

In the other type the driver's entrance is located forward of the front wheels. The battery either is carried underslung or mounted over the frame. In the underslung type, for the same load capacity, the overall length is considerably less than in designs of the first-mentioned type, with the added advantages of a greater economy of garage space, easy handling and maneuvering and a lower center of gravity. Chassis representative of this type of design are shown in Fig. 2. They are generally used on trucks of 1-ton capacity and over.

The inherent characteristic of the motive power for the propulsion of any vehicle is a decrease of speed when an increased effort is exerted. The series electric motor has this operating characteristic, since its speed varies as an inverse function of the torque or turning effort. Throughout its range of operation it likewise has a high value of torque per ampere drawn from the battery. Motors designed for the propulsion of electric vehicles may have either of the following typical speed-characteristics:

(1) Flat speed-characteristic, in which the speed does not drop rapidly on overloads; termed magnetically saturated

(2) Steep speed-characteristic, in which the speed drops more rapidly in overloads; termed magnetically unsaturated

There is no definite line of demarkation between the two types. Accepted practice designates a magnetically unsaturated motor as one in which the ratio of the torque at a 250-per cent load to the torque at full load, conventionally known as the torque ratio, is greater than 4 to 1.

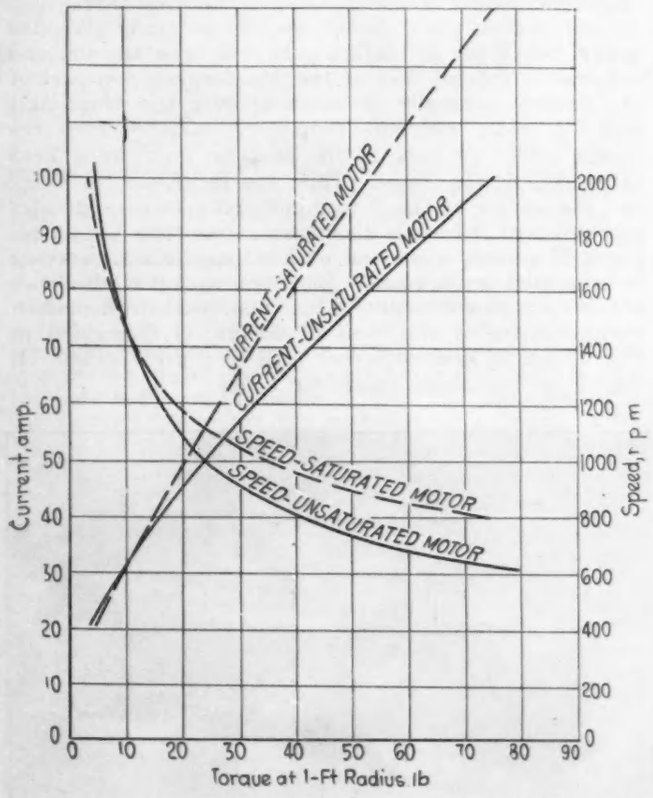


FIG. 3—COMPARISON OF SPEED CHARACTERISTICS OF MAGNETICALLY SATURATED AND UNSATURATED MOTORS

The Term "Magnetically Saturated" Is Applied to Motors Having a Flat Speed-Characteristic, in Which the Speed Does Not Drop Rapidly on Overloads, While Those Motors in Which the Speed Falls Off More Rapidly when Overloaded Are Termed "Magnetically Unsaturated" and Are Said To Have a Steep Speed-Characteristic

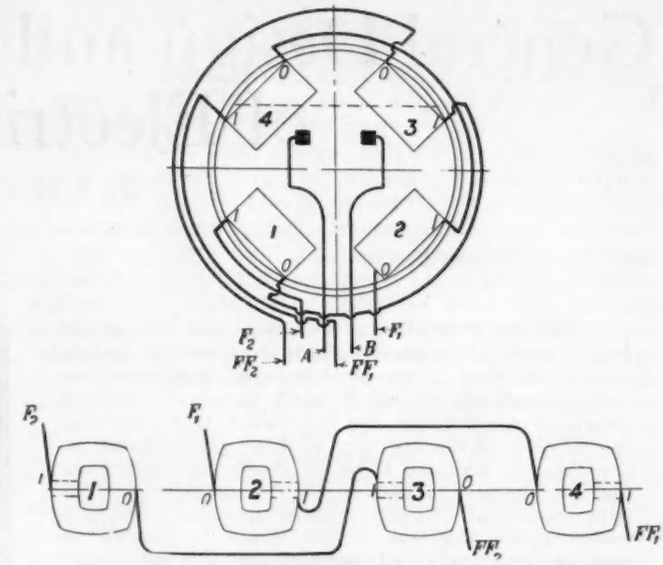


FIG. 4—TYPICAL CONNECTIONS FOR AN AUTOMOTIVE MOTOR

In Practically All of the Motors Used To Propel Electric Vehicles the Field Coils Are Grouped in Pairs and Arranged for Connection in Series or Series Parallel

A comparison of the two types of characteristic is illustrated in Fig. 3.

For application to an electric truck a motor having a steep speed-characteristic is preferable, in order that the battery will be protected when the truck is negotiating steep gradients, as it is more desirable that the available energy should be converted into high torque than into high speed.

The salient characteristics of automotive motors suitable for electric-truck propulsion may be briefly enumerated as follows:

(1) Ruggedness
(2) Durability
(3) Reliability
(4) Dependability

Practically all automotive motors have their field coils grouped into pairs and arranged so that they may be connected in series or series parallel as shown diagrammatically in Fig. 4. This arrangement results in two sets of speed-torque characteristics, the connecting of fields in series developing greater torques at lower speeds with less current drawn from the battery. For normal operation, the fields are grouped into series-parallel, the series connection being used only when developing high torque at low speed during the accelerating periods or when operating at low speed. Typical characteristics of an automotive motor are illustrated in Fig. 5.

The choice of one, two or four motors is dependent on the type of drive to be employed. The single-motor drive is generally favored because of its light weight, high efficiency and simplicity. The two-motor drive theoretically gives a slightly better performance when the stops per mile are very frequent, provided resistance is eliminated in the lower speed combinations of the controller; but it is extremely doubtful whether this apparent advantage will offset the additional weight of and maintenance required by an additional motor. For multi-stop service, the same efficiency that results from the use of two motors is obtainable by the use of one motor in conjunction with the grouping of the battery into two equal sections for connection in parallel and in series. This latter scheme of battery control eliminates resistance-operating speeds and results in the same half-

voltage and full-voltage at the motor terminals that are obtainable in the case of the two-motor drive when the motors are connected in series and parallel combinations. With the two-motor drive, field control of the motors is generally not incorporated into the control scheme. With a single motor and battery control, the motor fields are arranged in two groups, which may be connected in series and in multiple to secure more efficient operating speeds.

Selecting and Mounting of Motors

In selecting a motor for an electric truck, it has been determined by experience that a motor having a current-rating approximately equivalent to the current required to propel the truck on a hard level smooth pavement at

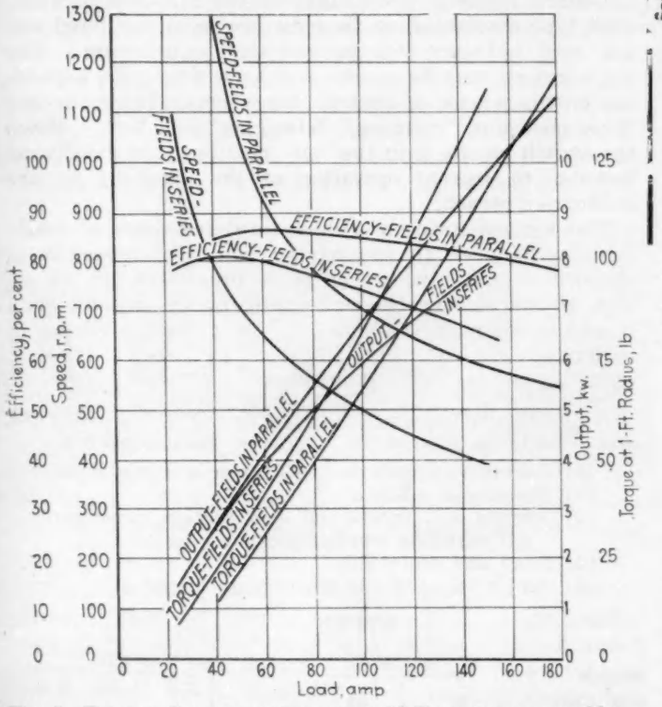


Fig. 5—Typical Characteristics of an 80-Volt Automotive Motor

its rated speed under full load, will, generally, be adequate for the truck under all operating conditions, as the motor will have ample overload capacity to provide for hills and emergencies.

An automotive motor is capable of developing extremely high torque and of withstanding extreme overloads. Illustrative of this is a brake test made on a particular motor under my supervision several years ago. The motor stalled at 75 per cent of its rated voltage. Under this condition the motor developed approximately 33 times its normal rated torque with a current of approximately 12 times the continuous rating in amperes. This high torque test is illustrated in Fig. 6.

There are approximately four general methods of locating or mounting the motor:

(1) On the chassis, forward of and connected with the rear axle through transmission members

(2) On the rear-axle housing, through a casting that houses the driving gears and is flexibly suspended from the chassis frame at the forward end of the motor

(3) In the rear-axle housing and driving the wheels through a balanced spur-gear drive

(4) Two motors mounted on the axle, each motor driving its wheel through a system of spur gears

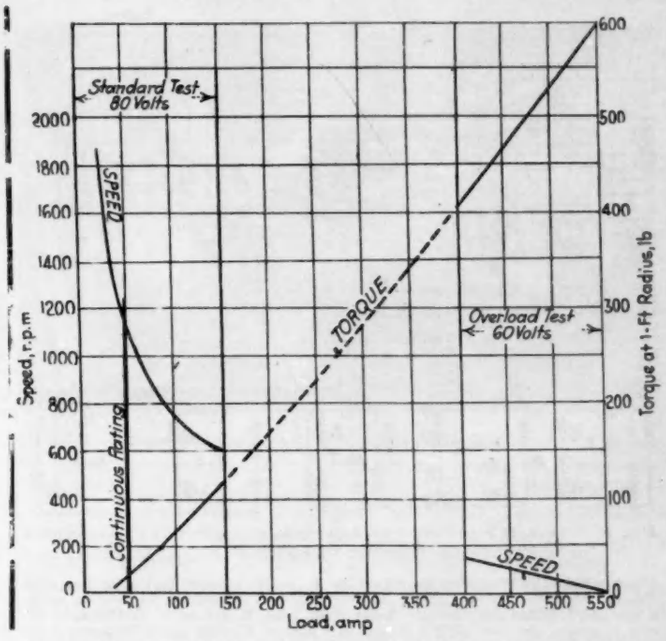


Fig. 6—Test Curves of an Automotive Motor That Was Subjected to Severe Load Conditions

In This Test the Motor Was Stalled at 75 Per Cent of Its Rated Voltage and under These Conditions Developed Approximately 33 Times Its Normal Rated Torque with a Current of About 12 Times the Continuous Rating

Control Equipment

The control equipment of an electric truck comprises principally the controller, the starting resistance and the main switch. Two general methods of control are in use on single-motor-drive trucks. In one the battery cells are connected permanently in series; in the other the battery is commutated, that is, the cells are divided into two equal sections for connection in parallel and in series combinations. In the first method, on light trucks, one resistance-step is generally used before the "field series" speed is reached, while on heavier trucks, two resistance-steps generally are necessary to secure smooth acceleration. A typical diagram of this type of control

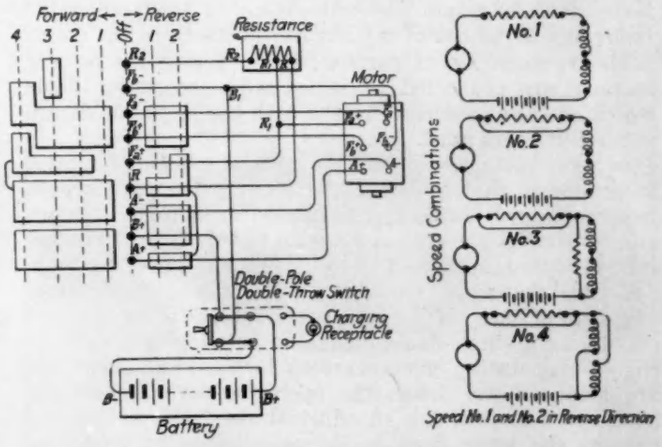


Fig. 7—Diagram Showing the Arrangement and the Connections of a Four-Speed Controller for Vehicle Motors

In the First Step, the Motor Fields Are Grouped in Series with a Starting Resistance; in the Second, the Resistance Is Short Circuited; in the Third, the Starting Resistance Is Still Short-Circuited but Another Resistance Is Connected in Parallel with the Fields; and in the Fourth, the Motor Fields Are Connected in Parallel with All the Resistance Short-Circuited. In This Controller the First and Second Speeds Are Also Available in the Reverse Direction

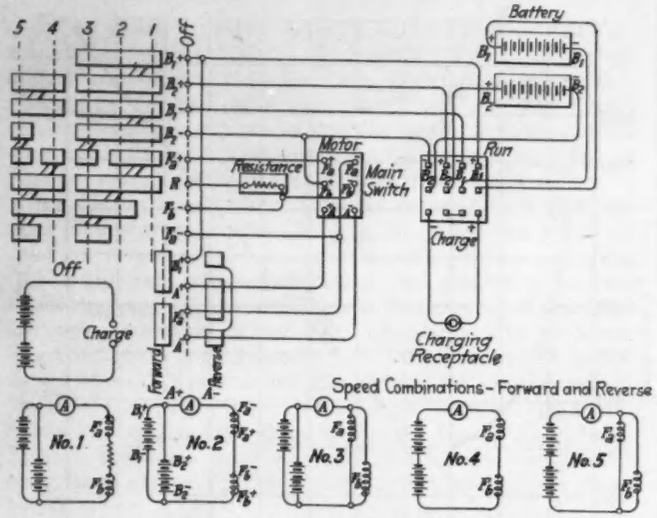


FIG. 8—DIAGRAM SHOWING THE ARRANGEMENT AND THE CONNECTIONS OF A FIVE-SPEED BATTERY COMMUTATING CONTROLLER

Connecting the Battery Sections in Parallel Gives Half the Normal Operating Voltage with the Motor Fields Connected in Series with a Single Resistance; in the Next Step, the Resistance Is Cut-Out of the Circuit; in the Third Step, the Motor Fields Are Connected in Parallel instead of in Series; the Battery Sections Are Connected in Series with the Motor Fields Which Are Also Connected in Series; in the Final Step the Motor Fields Are Connected in Parallel instead of in Series. With This Controller All Speeds Are Available in Both Directions and a High Operating Efficiency in the Multi-Stop Service, Which Has Numerous Accelerating Periods, and Economical Operation at Low Speed in Congested Traffic Zones Are Secured

is reproduced in Fig. 7. In the first speed-combination the motor fields are grouped in series with a starting resistance; in the second the resistance is short-circuited; in the third a resistance is placed in parallel with the fields; and in the fourth the motor fields are connected in parallel without resistance.

The second method of control results in a high efficiency of operation in multi-stop service, in which the accelerating periods are numerous. It also allows economical operation at low speed in congested traffic zones. A typical diagram of this type of control is presented in Fig. 8. In the first speed-combination, connecting the battery sections in parallel provides one-half the normal operating voltage, with the motor fields connected in series with a single resistance-step; in the second the resistance is cut-out of the circuit; in the third the motor fields are connected in parallel; in the fourth the battery sections are connected in series with the motor fields which are also in series; in the fifth the motor fields are connected in parallel.

In a two-motor equipment the general scheme of control is similar to that of single-motor equipment, the speeds being obtained through combining the motors in series and in parallel. A typical diagram of this type of control is reproduced in Fig. 9.

Controllers must be designed so that compactness, ruggedness, ease of operation and accessibility are secured. In a single-drum controller in which the connections for operating the truck both forward and backward are made on one drum, the operating lever is usually placed in a slot having an offset at the "off" position to prevent the lever from being moved directly from the forward to the reverse position.

When controllers employ two drums, a main drum for controlling the speed combinations and one for reversing the drums usually are interlocked, so that the reverse drum will be inoperative when the main drum is in any "on" position. It is necessary to return the main drum to the "off" position before the reverse drum can be operated. The reverse drum on Walker trucks is operated by a pedal, against the action of a spring, which returns the reverse drum to the forward operating position, when the pressure on the pedal is released and the main drum is returned to the "off" position.

Various speed-combinations of the controller are indicated by the action of a pawl and a star wheel. The controller may be located under the seat, with the operating handle at the driver's left, on the steering column, or between the side-rails. In the last-mentioned method of mounting, the controller is operated by a lever that extends through the cab floor, or by a lever on the steering-column, which is connected to the controller through a system of linkage.

Control resistors are usually of the cast-iron or alloy-grid type assembled on tie-rods, are mica insulated and are held between two pressed-steel end-frames. The main switch may be single, double or four-pole, depending on the scheme of control connections. It usually has three positions, "running," "charging" and "off." When the switch handle is in the "off" position it is usually removable to prevent operation of the truck by an unauthorized person.

The highest grade of rubber-insulated cable of ample capacity is used in the wiring, which is installed in metallic conduits whenever it is practicable to do so. Fig. 10 shows how the entangling of the wiring on a truck chassis may be avoided by installing the wiring in conduits.

BATTERIES

A storage-battery to fulfill the requirements of truck operation must possess the following characteristics:

(1) Ability to propel the truck up severe gradients
(2) Reasonable efficiency
(3) Rugged and substantial construction, capable of withstanding service shocks
(4) Long and useful life
(5) Ample capacity for the purpose intended

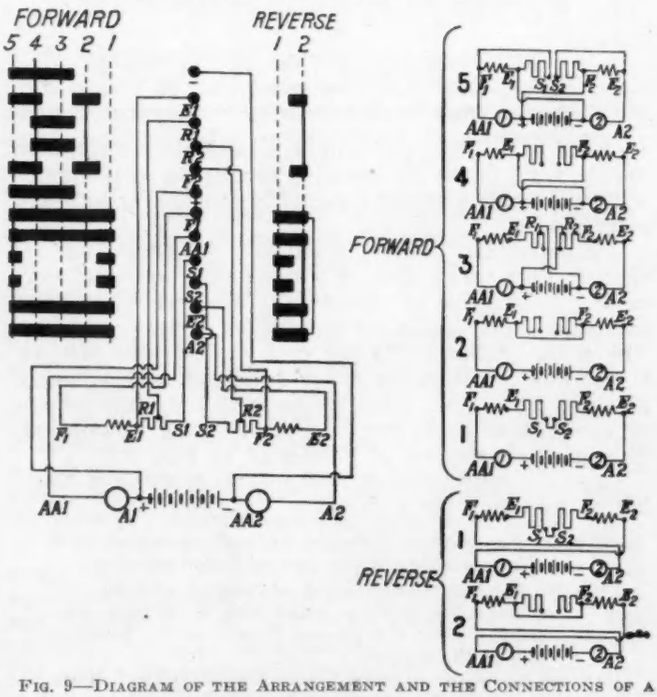


FIG. 9—DIAGRAM OF THE ARRANGEMENT AND THE CONNECTIONS OF A TWO-MOTOR CONTROLLER

This Controller Provides Five Forward and Two Reverse Speeds, All of Which Are Obtained by Connecting the Motors in Series and in Parallel in Much the Same Way as the Fields of a Single Motor Are Connected in the Diagrams Reproduced in Figs. 7 and 8

Improvements in recent years enable batteries to fulfill these requirements.

The recommendation of the Society[2] regarding the number of battery cells for electric trucks is as follows:

> For electric passenger cars and trucks, the number of cells in lead-acid storage-batteries shall be 42 and the number of cells in nickel-iron storage-batteries shall be 60.

Final-Drive

Electric trucks are generally driven from the rear wheels. The problem of the final-drive involves essentially the transmission of power from the revolving shaft of one or more motors to the driving wheels, which are flexibly connected to the frame through the axle and the springs, and the simultaneous reduction of the relatively high rotative speed of the motor shaft or shafts to the relatively low speed of the driving wheels. Transmission or driving systems embody various combinations of chain, bevel-gear, spur-gear and worm drive. Most trucks in the past have been equipped with chain drive; in recent practice, however, the chain drive is not extensively used.

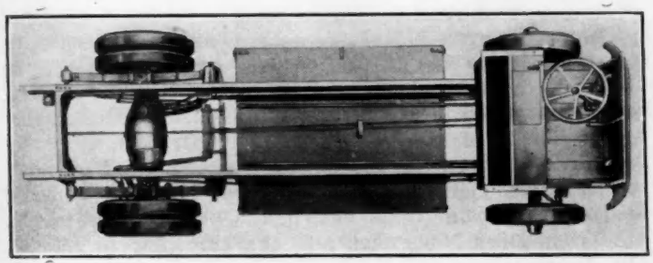


Fig. 10—Plan View of the Chassis of a 5-Ton Electric Truck
The Use of Rubber-Insulated Cable and Metallic Conduit Gives a Neat Installation and Avoids Tangled Wiring

The bevel-gear drive, although not now applied to electric trucks of greater capacity than 1 ton, is satisfactory for light delivery trucks in which the torsional stresses in the rear axle are such that it is possible to design bevel gears that will give the required speed-reduction without the axle becoming unwieldy or handicapping the motor by its size or electrical characteristics. In light trucks the lower motor-speed required with a bevel-gear axle does not necessitate a greater gear-ratio than is readily obtainable. The bevel-gear axle is generally of a fixed-hub or semi-floating type. Bevel-drive gears usually are of the helical type. Worm-drive axles are used on some makes of light and of heavy electric trucks.

Several types of double-reduction drive in use are combinations of bevel and spur gears. In one type the bevel-gear set forms the first reduction, and the spur gear the second. In another design the second reduction is by spur pinions that mesh directly with internal gears in the wheels, the bevel gears and the differential forming a drive unit that is bolted to the motor and suspended in the frame, the drive being taken from each side of the differential by two universal-shafts to the wheel-drive pinions. In another type the order is reversed, the spur-gear set forming the first reduction and the bevel-gear set the second.

A number of special spur-gear drive systems are in use. In the Walker balance-drive type, illustrated in Figs. 11 and 12, the motor differential and the power drive members are embodied in the rear axle and the

[2] See S. A. E. Handbook, p. B102.

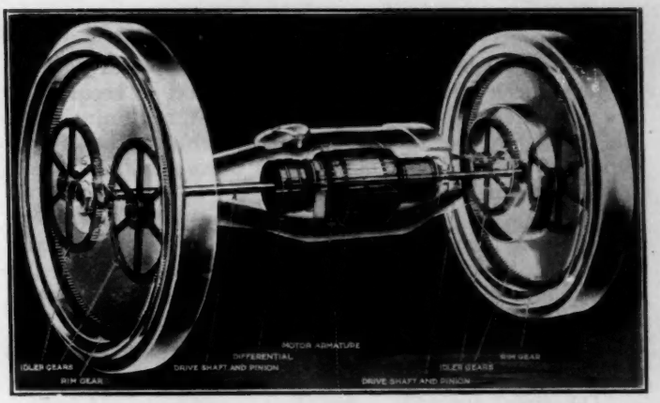


Fig. 11—Phantom View of a Spur-Gear Electric-Vehicle Drive
In This Drive the Motor Differential and the Power Drive Members Are Embodied in the Rear Axle and the Wheel Assembly and a Hollow Torpedo-Shaped Housing Encloses the Motor and Secures the Stub Axles or Yokes That Carry the Wheels and the Gearing

wheel assembly. A hollow torpedo-shaped housing encloses the motor and the differential, and secures the stub axles, or yokes, which carry the wheels and the gearing. The ends of this housing are bored to receive the stub-axle bodies and are slotted on the underside to provide a means for "pinching" the stub-axle body. On the upper side of the bore of each end of the housing a keyway is cut to prevent the yoke body from turning because of torque reactions. The housing forms the magnet frame of the motor, the inner surface being machined cylindrically for the pole-pieces and the field-coils. The motor armature is built on a spider having a large bore into which a forged hollow-steel shaft of large diameter is pressed. On one end of the armature shaft is a flange to which the differential is bolted. Two drive-shafts extend from the differential side-gears into the center of each rear wheel, the longer one extending through the hollow armature-shaft.

The stub-axle or yoke bodies are made of forged heat-treated-steel. Yoke arms support the idler-gear bearings, maintaining the proper gear-center distances of the idler gears in relation to the pinion and the internal gear.

The hollow rear-wheels encasing the driving gears are dirtproof and waterproof and contain lubricant, which is distributed continuously and automatically over all the working parts by rotation of the wheels. They are

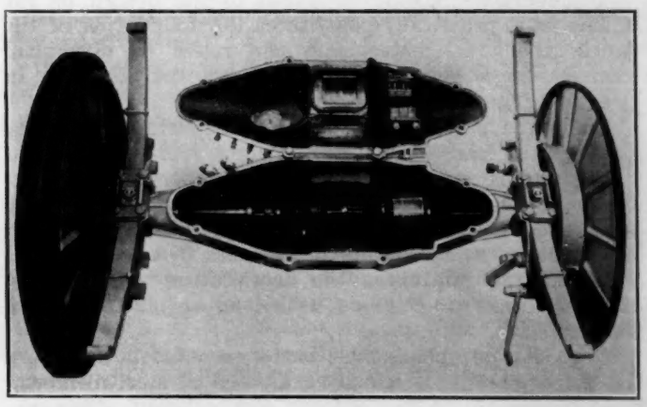


Fig. 12—View of the Motor Assembly of the Drive Illustrated in Fig. 11
The Axle Housing Forms the Frame of the Motor and the Motor Armature Is Built on a Spider and Has a Flange at One End to Which the Differential Is Bolted. Shafts Extend from the Differential to the Center of Each Rear Wheel, the Longer One Extending through the Hollow Armature Shaft

mounted on roller or ball bearings, supported by the stub-axles.

Each drive-shaft pinion engages two idler gears, which in turn mesh with the internal gear that is secured to the permanent wheel-band. Briefly stated, beginning with the motor, the power is transmitted through the direct-connected differential and the two drive-shafts that extend from the differential side-gears to the centers of the rear wheels. Drive-shaft pinions transmit the power through the idler gears to the internal gears, which are secured to the permanent wheel-band. The drive-shafts and pinions have no bearings except the teeth of the idler gears, between which the pinions float under the influence of diametrically balanced forces.

This drive has several distinctive features:

(1) Simplicity. The powerplant is self-contained and has few and simple parts
(2) Low maintenance. All moving parts are in permanent alignment and are fully enclosed yet accessible
(3) Balanced drive
(4) Low stresses in the drive shafts and the gearing
(5) Sustained uniformly high efficiency. Tests made by the Armour Institute of Technology show that uniformly high efficiency is obtained at practically all speeds and loads. Tests indicate a uniform efficiency of from 97 to 99 per cent
(6) Self-lubrication. All gears operate constantly in lubricant

Design Fundamentals

Approximately five general methods are used to provide for the torsion and propulsion stresses in shaft-driven axles, which in electric-truck design follow the same practice prevailing in gasoline-truck design. In general, the torsion and propulsion stresses are taken through the springs, a system conventionally known as the Hotchkiss drive.

The brake design conforms to accepted gasoline-truck practice. On trucks having a propeller-shaft, one brake may be mounted either at the front end of the motor or at the front end of the propeller-shaft, with an additional set on the rear wheels, or both sets may be mounted on the rear wheels. Rear-wheel brakes are generally used on electric trucks. The front axles and the steering mechanisms of electric trucks also conform to the accepted practice of gasoline-truck design.

Consideration should be given to the design of the frame as it practically constitutes the foundation of the truck, the pressed-steel and the rolled or structural channel types being principally used, the same as in prevailing gasoline-truck design.

When the battery is underslung amidships, the compartment is carried by steel members from the main frame and is supported by truss members that extend from the lower extremities of the battery compartment to the side-rails. This produces a very substantial frame construction, which results in stiffness in a longitudinal direction and minimizes the accelerating and braking strains, shocks of collision with loading platforms and the like.

When the interchangeable battery system is not used, the battery cradle is usually composed of steel members riveted securely to the battery compartment structure.

In the interchangeable battery system the accepted types of cradle are

(1) The Stone
(2) The wheel-type
(3) The skid-type

Structurally, these cradles may be similar in design, the cradle proper being fabricated from angles, with steel strips or angles that form part of the battery-tray supports. The four sides of the cradle may be formed by angles firmly riveted together. Two angles extending across the cradle longitudinally form the support for the inner ends of the battery trays.

In the Stone interchangeable battery cradle, dowel-pins are riveted into each of the cradle transverse angles. These dowel-pins engage holes in the lower transverse members of the battery compartment, securing the static position of the cradle and permitting the quick interchange of cradles by lifting the cradle with an elevating platform hand-truck. In the wheel-type cradle, wheels are mounted on the cradle transverse angle-members, the lower transverse members of the battery compartment forming the runway or track. In the skid-type cradle, a treated maple skid is fastened under each of the cradle transverse angles, the lower transverse angle-members of the battery compartment forming the runway for the skids.

Battery trays must be effectively retained to prevent the shifting of the trays when the truck is in service. The design of retainer varies with the method used.

In designing a battery compartment the accessibility of the battery for inspection and watering should be carefully considered. The construction of the compartment illustrated in Fig. 2 renders the battery particularly accessible as battery-box covers and doors can be easily removed.

The arrangement of a structural seat-box housing the controller, the main switch, the ampere-hour meter, the light-circuit switches and the charging receptacle, as illustrated on the chassis in Fig. 2, is distinctly advantageous since it renders the chassis a self-contained operating unit ready for the body and the cab. The chassis frame is supported on the axles by steel leaf-springs, which are practically all of the semi-elliptic type.

Three types of wheel are used on electric trucks at present: wood wheels of the artillery type, pressed-steel and cast-steel wheels. The operating speeds are such that solid tires are particularly adaptable to electric trucks and result in the lowest tire maintenance. Some manufacturers fabricate solid tires from special compounds particularly for electric-truck service. These "electric-compound" tires are resilient and show high operating efficiency and long life.

Choosing Between Gasoline and Electric Trucks

A choice between gasoline and electric trucks depends on the following fundamental conditions:

(1) Length of the route
(2) Character of the roads
(3) Speed requirements
(4) Number of stops
(5) Traffic

The electric truck is capable of operating from 40 to 50 miles on a single charge of the battery, which is sufficient for practically any city route. One large department store reports an average of 30 miles per day for its entire fleet of 276 electric trucks. The American Railway Express Co. states that the average daily travel of its electric trucks is approximately 20 miles. In ice-cream delivery service on city routes the average distance negotiated daily is from 20 to 30 miles for 3½ and 5-ton trucks. Bakeries, laundries, dairies and many other large users of electric trucks report similar mileages over city routes. A study of the maps of 68 large cities in

the United States, representing a corporate population of 27,000,000 people, indicates that a daily operating range of 40 miles will cover approximately 85 per cent of all the deliveries on city routes. The foregoing data show clearly that the operating range of electric trucks is ample to meet the requirements of most city-delivery routes. Some of the outlying suburbs of New York City, Chicago, Philadelphia and Boston may appear to be outside this range, but with a proper layout and organization of the delivery system electric trucks could be used economically in such service. Topographical conditions are, generally, not a barrier, as is evidenced by the successful and economical operation of electric trucks in such hilly cities as Pittsburgh, Kansas City and San Francisco, where the service is particularly severe on gasoline trucks and horses.

The operating speeds of electric trucks range from 10 m.p.h. for a 5-ton truck to 18 m.p.h. for a ½-ton truck. Although it is true that the maximum speed of an electric truck is lower than that of a gasoline truck of similar capacity, it has been proved in service that the speeds of electric trucks are adequate for city routes. That excessive speed greatly increases the cost of maintenance and operation, particularly in multi-stop service, should not be forgotten. On a straight-away run, the gasoline truck would have an advantage over the electric truck from the standpoint of time-saving. In multi-stop service, however, the disparity disappears entirely and the electric truck has an advantage because of its ability to accelerate more rapidly than a gasoline truck. In operating over a 30-mile average city-delivery route with 100 stops, the difference between the average speed of electric trucks and that of gasoline trucks was approximately ½ m.p.h. In congested traffic zones the superior accelerating characteristics of the electric truck give it an additional advantage.

A distinctive advantage of the electric truck is that when the truck stops all the moving parts stop. The truck starts instantly upon the application of power and accelerates rapidly. On the other hand, it is very unusual for a driver of a gasoline truck to shut off the engine at every traffic or delivery stop. In multi-stop service and in congested traffic-zone operation, this advantage of the electric truck is of considerable importance. On an average 30-mile city route and during 8 hr. of elapsed time, trucks are in motion only 2½ to 3½ hr. As the engine of a gasoline truck will operate practically continuously throughout the entire 8 hr., this means a waste of power and a reduction in the life of the mechanical parts, with consequent high operating cost and decreased useful life.

Electric trucks are claimed by their advocates to be more economical and satisfactory than gasoline trucks or horses for approximately 85 per cent of all city routes. They possess the following distinct advantages:

(1) Economy
(2) Simplicity
(3) Dependability
(4) Reliability
(5) Durability
(6) Cleanliness and freedom from contaminating odors
(7) Freedom from high temperatures
(8) Ease of operation and maintenance
(9) Minimum fire-hazard

The salient characteristics contributing to these advantages may be briefly summed up as follows:

(1) Substantial construction and the absence of the reciprocating internal-combustion power-unit practically eliminate road troubles, reduce maintenance expense to a minimum and obviate the necessity of high-priced mechanics
(2) Minimum vibration, freedom from adjustments and the prevention of careless and reckless speeding prolong the useful life of the electric truck to more than double that of the gasoline truck
(3) Reliability and uniform driving-power throughout the entire life of the electric motor, which delivers its maximum power to the driving wheels automatically as it is required
(4) Operation at safe economical speeds due to the inherent characteristics of the series motor, the speed of which decreases automatically with an increase of load

Analyses of the performance and the cost of gasoline and of electric trucks under conditions of competitive operation over long periods show conclusively the striking economy of the electric truck from the standpoints of power consumption, tires, oil and grease, maintenance, garage expense and life of equipment.

That electric trucks are dependable and reliable has been proved conclusively in service, particularly in New York City and Boston during the severe snowstorms of last winter and of the winter of 1919-1920. In one fleet of over 300 electric trucks operating in New York City during a very severe snowstorm only 13 cases of trouble were reported. Of these only seven were important. Only three had exhausted batteries, but even these trucks had practically completed their day's work. Electric trucks were operating when other transportation was tied up. Their ability has been demonstrated also by the record of 722 electric trucks in the service of a transportation company in Atlanta, Buffalo, Chicago, Cleveland, Detroit and the City of Washington. These trucks during the year 1922 were in service a total of 226,716 days, or more than 314 truck-days per year, for a total of 4,987,752 miles. During this period the trouble calls were fewer than two per truck per year. The calls incident to exhausted batteries averaged only one per truck in 2 years of service. The ability of electric trucks to give continuous service day after day and year after year is a factor of great importance to anyone who is concerned with delivery schedules.

The cleanliness and the sanitary quality of electric trucks, together with the absences of high temperatures, are self-evident to anyone who has examined an electric truck or visited an electric-truck garage, while freedom from objectionable odors and smoke is a particularly desirable feature in the delivery of foodstuffs.

The electric truck has firmly established itself as one of the greatest economic necessities of urban industry and is replacing horses and gasoline trucks where they have been misapplied to trucking systems on city routes.

THE DISCUSSION

J. G. CARROLL:—So far as the relative unsprung weight in gasoline and electric trucks is concerned, we must consider the difference between the two types of truck and their driving mechanisms. First of all, in an electric truck we have a constant uniform driving-torque as compared with the non-uniform driving-torque of the gas engine of the other type truck. Secondly, the speeds of electric trucks are relatively slower than those of gasoline trucks of equivalent capacity. Theory as well as practice indicates, so far as life and maintenance are concerned, that the electric truck, notwithstanding its relatively greater unsprung-weight, has a longer useful life than the gasoline truck.

Practically all electric-truck builders use high-grade alloy steels in the axle. For example, in the axle illustrated in Fig. 11, the housing, which also forms the magnet frame for the motor, is of electric-furnace steel. The motor conforms to other traction motor design, and the highest grade of materials, copper, insulation and iron, is used in its construction. The drive-shafts are chrome-nickel steel.

The comparison of gasoline and of electric truck operating costs I cannot give, as I have no definite figures. I can say this, however: In the same service, performing the same work, the electric truck operates more cheaply than the gasoline truck when the operation is within the zone of electric-truck operation. There are today three fields of highway transportation, covered respectively by the horse, the electric truck and the gasoline truck. None of these can cover the whole field. Judging from the studies that have been made, it seems that 85 per cent of city-delivery routes are really economic routes for electric-truck operation.

GEORGE E. MARTIN:—There is a dividing or border line near which the two types of truck are equal.

MR. CARROLL:—That depends entirely on the system of costs that is kept when operating the two types of truck, and much depends on the city in which they are operating. I do not believe that anyone can work out a line of demarcation between the electric-truck zone and the gasoline-truck zone; or that anyone would attempt to define the radii of electric-truck and of gasoline-truck operation so far as cities are concerned. I am speaking principally of city routes.

The electric-truck industry does not intend to convey the impression that the electric truck can be operated on any and all routes; that is the reason I brought out the fact that its application is dependent on the length of the route, the character of the roads, the speed requirements, the number of stops and the traffic conditions. Each problem must be studied individually to determine the applicability of the electric truck, the gasoline truck or even the horse-drawn vehicle.

MR. MARTIN:—Do not some of the larger companies, like the American Railway Express Co. and Marshall Field & Co., operate both kinds of truck and switch from one service to the other?

MR. CARROLL:—No; generally not. The two types are used for distinct services. Marshall Field & Co. use gasoline trucks principally for distributing to the distribution centers and in some cases electric trucks in this service, depending entirely on the layout of the delivery system. The weights of the electric truck are dependent on the service requirements to a considerable extent; that is, the size of battery required. The figures given in Table 1, which are based on the specifications printed in one of the trade journals,[3] give the comparative chassis weights of a number of representative gasoline and electric trucks.

MR. MARTIN:—Please give us an idea of the units in an electric truck that give the most trouble in design or construction or in securing the right materials. What are the things that seem to bother most in electric trucks in general?

MR. CARROLL:—So far as design goes, the principal difficulty is the selection of a proper motor for the truck. When you apply a certain engine to a gasoline truck, you cannot change its characteristics, except within certain limits, whereas with an electric motor the torque ratio may be varied from 3 to 1 up to 5 to 1. The efficiency may be varied from 80 to 92 per cent. There are economic limits regarding which the designer will have to form his own conclusions as to how far he wishes to go with torque and efficiency in the motor design. This is the principal difficulty in designing an electric truck. Once the motor characteristics have been decided upon and the motor has been built, a desired change necessitates revising the whole design and changing the motor characteristics; not an economical thing to do.

TABLE 1—COMPARATIVE CHASSIS WEIGHTS IN POUNDS OF A NUMBER OF REPRESENTATIVE GASOLINE AND ELECTRIC TRUCKS

	1-Ton	2-Ton	3½-Ton	5-Ton
Gasoline Trucks				
Diamond T	....	....	7,250	8,790
G.M.C.	3,250	5,300	7,945	8,645
Garford	3,500	....	....	9,350
Mack	....	5,400	7,970	8,550
Pierce-Arrow	....	6,000	8,300	9,300
White	....	4,815	7,300	7,950
Electric Trucks				
Commercial Truck, without battery	2,400	4,000	5,000	6,500
Commercial Truck, with battery	3,900	6,000	7,600	9,700
Walker Truck, without battery	2,800	3,800	5,600	6,400
Walker Truck, with battery	4,200	5,800	8,200	9,600

In selecting a motor for an electric truck it behooves the designer to have clearly fixed in mind the characteristics desired. Efficiency can be varied within reasonable limits from low to high and the torque ratio from low to high. Varying them affects the motor design very materially. The gear-ratio, or speed reduction, as on gasoline trucks, is practically fixed by the materials at hand.

Experience has taught us that, if we apply a motor having a continuous rating, such that when the truck is operated at full load and at its rated speed on smooth level pavements, the current drawn is equivalent to the rating of the motor, there will seldom if ever be trouble with that motor so far as burn-outs are concerned.

O. W. YOUNG:—Is the ratio of the battery weight to the total vehicle weight constant throughout the different sizes and about what are the ratios?

MR. CARROLL:—The ratio of the battery weight to the total vehicle weight would not be constant; it would be a varying curve depending entirely on the type of battery used and the capacity of the battery required for the service. Ordinarily in a 5-ton truck the battery will weigh somewhere between 3000 and 4000 lb.; in some cases it may be even less.

CHAIRMAN TALIFERRO MILTON:—On the average is a full battery-charge or less than a full battery-charge used?

MR. CARROLL:—In most cases it is less than a full battery-charge; the battery is designed to take care of emergencies. In some emergency cases the battery is completely exhausted. In a certain installation I have in mind, 75 per cent of the battery capacity is seldom used at any time and the excess is available to give an additional mileage-range in case it is desired. This is really an asset in certain types of battery, because it results in a longer life and lower maintenance. In the alkaline battery, a complete discharge every day will enable the battery to give better service, a higher average

[3] See *Automotive Industries*, Feb. 22, 1923, p. 404.

(*Concluded on p.* 35)

Importance of Better Automobile Head-Lamps and Proper Adjustment

By R. N. FALGE[1] AND W. C. BROWN[1]

METROPOLITAN SECTION PAPER

THE discussion of this paper as printed herewith is that presented at the Metropolitan Section Meeting held on Sept. 20, 1923. An abstract of the paper, as then delivered, precedes the text of the remarks made at the meeting.

Subsequent to the presentation of the original paper at the 1923 Semi-Annual Meeting, at Spring Lake, N. J., which was published in the July, 1923, issue of THE JOURNAL on p. 25, the subject matter indicated in the last paragraph of the following abstract was added and the paper was revised, the latter being, however, mainly a rearrangement of the material and the illustrations. The portions added are readily discernible by referring to the account of this meeting that was published under the title Head-Lighting Without Glare, on p. 350 of the October, 1923, issue of THE JOURNAL.

ABSTRACT

THE accurate construction and easy adjustability of automobile head-lamps, though they have received much attention, are still susceptible of further improvement. If motorists realized that the road would be illuminated better, objectionable glare could be avoided and a better and safer head-lamp would be secured by properly adjusting the head-lamps now in service, an immediate and far-reaching improvement would be effected.

Views are given of tests made with the common type of head-lamp with a parabolic reflector to show the effects produced by placing the source of light at the focal point, by moving it forward, backward, above and below this point, and also by cylindrical flutes in the glass and by horizontal prisms. The head-lamp is shown to be very sensitive inasmuch as the distances from the filament to the reflector are very short when compared with those to which the light is projected. A type of lens is described that will compensate for the commercial variations in the position of the filament and at the same time distribute the light effectively, converging or diverging the rays laterally while maintaining the top or cut-off substantially at the level of the head-lamp. As the maximum intensity should be placed as near to the top as possible to illuminate the road-bed most effectively, and as the eye accommodates itself slowly to changes of intensity, the lens takes advantage of these characteristics by spreading and bending the light in each zone by different amounts.

The requirements are given for the uniform and satisfactory service of lamps and of such parts as filaments, sockets, reflectors, lenses, doors, and mountings, the underlying idea being the use of devices that will obviate the necessity for focusing and leave to the motorist only the simpler adjustment of aiming.

Other features include a discussion of the advantages of using horizontal prisms, of the possibilities of simplifying necessary head-lamp adjustments, and a detailed statement of the procedure of head-lamp adjustment.

[1] Engineering department, National Lamp Works, General Electric Co., Cleveland.

THE DISCUSSION

A. W. DEVINE:—I am much interested in Mr. Falge's point regarding the fixed-focus lamp. The efforts of some of the prominent lamp manufacturers to produce precision bulbs of greater accuracy leads me to ask when the manufacturers of reflectors can be depended upon to increase the accuracy of their product so that the bulb and the reflector can be used together with no focusing adjustment. If we could get accurate bulbs and accurate reflectors, we could use lenses without focusing adjustments of any kind in the lamps, and simply tilt the lamps down until the top of the beam was a sufficient distance below the lamp center, as Mr. Falge has illustrated, to allow for the loading of the car. Our experience in Massachusetts has been that the loading allowance is extremely important. Automobile traffic has increased to such an extent that it is almost impossible to go anywhere on any road and not find motorists coming from the opposite direction. If it were not for these conditions, the spotlight would prove a valuable accessory for night driving at relatively high speed, but if Mr. Falge drove in Massachusetts I think he would not get much chance to use it.

Ten of the Eastern States have formed a Conference that has for one object the unification of the laws of bordering States that conflict to such an extent that they cause inconvenience to operators going from one State into another. The laws particularly considered are the laws relating to head-lamps and the lighting of vehicles. These 10 States have now adopted a uniform list of head-lighting devices so that it is possible for an operator whose car is equipped with one of them to go from one State into any neighboring State in the East without violating the lighting laws, provided, of course, that the lamps are adjusted properly.

To get motorists to adjust their head-lamps is difficult. In Massachusetts we have started, probably, a more severe enforcement of the lighting laws than any other State has ever attempted. A campaign that began Sept. 1, 1923, is on at the present time. Inspectors are out on the road reporting violations of the lighting laws. There are 12 of these inspectors and, in the first two weeks of September, between 4000 and 5000 complaints were turned in. That indicates the necessity for adjusting lamps properly. We thought we had accomplished something last year. In the first year after our law went into effect, we reduced the night accidents, due to lighting conditions, by 50 per cent; but this year, on account of the large number of applications for licenses, the investigators from our department have been pretty well tied-up. Examinations have been running at the rate of 20,000 or more per month, so that the enforcement of the lighting law has suffered and the result is astonishing. In the months of July and August, 1923, night fatalities increased 100 per cent over those for the same months of 1922. As soon as these figures were available we started the compaign that is at present under way.

The point I should like to bring out from these figures is that in one year we made an appreciable improvement in lighting conditions; but, because of conditions in the department, we were unable to continue the enforcement for a period of 8 months this year, and in that time the good conditions that we had obtained went all to pieces. Everything went back to the old conditions that existed 2 years ago and we had to start again with our campaign. We hope very much that this fixed-focus idea will be expanded so that it will take the complicated, so the motorist thinks, adjustment away from him, and all he will have to do is to tilt the lamp down.

H. K. MAPLES:—By establishing head-lamp testing-stations throughout the State, we are trying to eliminate many of the glaring head-lamps on the road. One of the obstacles that we have had to meet is the lack of uniformity in both the lamp and the reflector. We have found, in many cases, that motorists have gone to testing-stations and had their lamps tested and adjusted, and because possibly of poor manufacture of the reflector, the lamps or the socket, the lamps have stayed in adjustment but a very short time.

In some cities we have gone so far as to get the co-operation of the local police and, in some cases, of the State police. We have issued a sort of certificate to the motorist to show that he has complied with the law. Strange to say, shortly after this certificate was issued to a motorist, he was stopped again and checked-up; and his head-lamps were found to be far out of adjustment. He cannot be blamed and neither can the testing-station; both are sincere in their efforts to comply with the law. But we feel that we can blame the manufacturer. I think that, as a whole, motorists throughout New York State, having seen for themselves some examples of what real focusing and tilting will do in the way of better lighting, have come to feel that they have been abused. Many motorists would like to know when legislatures really will stop making these laws. We have given them certain lenses that are approved by the State, but the State has not set down any standard in the way of a reflector and a socket. I had an unfortunate experience myself in buying new sockets and new lamps for my own car and had a hard time focusing them. Speaking for the motorist, I think that one of the big tasks that engineers could accomplish is to standardize the sockets and the reflectors.

R. E. CARLSON:—The specifications worked out by the Illuminating Engineering Society and approved by the Society of Automotive Engineers for regulatory purposes provide a means of determining whether a particular lens is satisfactory. Based on these specifications, the Conference of Motor Vehicle Administrators, representing 10 States, has prepared a uniform approved list of devices that are legal in these 10 States. None of the 27 devices on the approved list will be satisfactory, however, unless it has been adjusted properly. The lens described in the paper is therefore of particular interest, inasmuch as it minimizes the work required to secure the proper adjustment of head-lamps.

The Bureau of Standards has assisted in the preparation of the Illuminating Engineering Society specifications and is also interested in the subject of the proper adjustment of head-lamp devices. In a test of some 400 cars in the District of Columbia, it was found that only 5½ per cent had lamps properly adjusted, although 73 per cent of the lenses were of approved types.

We believe that the solution of the problem of the better adjustment of head-lamp devices requires the wholehearted cooperation of all parties interested. We have endeavored to make sure that the head-lamps on all new cars delivered by dealers have their lights properly adjusted and, to accomplish this, we have worked through the local Automotive Trade Association as well as with the individual dealer. Letters from some 50 automobile companies indicated a rather wide difference in practice, some car-builders exercising supervision over the head-lamp adjustment through their dealers, while others apparently gave little attention to this phase of the work. We believe that the automobile builder's responsibility for good head-lamp adjustment does not cease until the car has been turned over to the buyer and each buyer understands the importance of this subject.

Head-lamps may be adjusted properly at the factory but, during shipment or delivery to distributors, be thrown out of adjustment. If the distributor does not check-up further after he receives the car, one more car may be placed in the hands of the public with lamps improperly adjusted. In the City of Washington, most of the dealers have agreed to include head-lamp adjustment in the servicing of used cars and have erected adjusting screens that are used for them as well as for new cars.

Strangely enough, the company whose car is complained of most frequently for having blinding lights has created the best machinery for securing head-lamp adjustment. The difficulty is that the individual car-owner does not take advantage of the facilities offered through the various agencies of this company. If the factories could absolutely guarantee that the 2,000,000 or 3,000,000 new cars turned over to the public annually will have properly adjusted head-lamps, this would be a step forward in the solution of the problem; and I believe that this is a phase of the work in which the Society can take an active part.

In an attempt to reach the individual car-owner, the Bureau of Standards has cooperated with the National Motorists Association and the American Automobile Association. Instructions and charts for the adjustment of head-lamps were prepared and some 18 or 20 garages through whom these associations operate in the District of Columbia were fitted-up with facilities for head-lamp adjustment. The membership of both associations was notified and cards were furnished by which individuals could have their head-lamps adjusted without charge. This service was also available to non-members at a nominal charge. In addition, these national associations have communicated with their member clubs throughout the Country and have furnished instructions and charts. Through these two associations in the District of Columbia, we have reached probably 8000 or 10,000 car-owners and, in addition, have equipped 20 garages to test head-lamp adjustment. The Bureau of Standards maintains a testing screen, where daylight tests can be made, and has been adjusting on an average three or four sets of head-lamps per day.

The Washington Safety Council is interested in head-lamp adjustment from the standpoint of street safety, and has lent its aid through its poster service. About 100 posters were displayed in prominent parts of the city and several hundred additional posters were carried on street-cars, trucks, taxicabs and the like, bearing the following reminder: "Blinding Head-Lamps are Dangerous and Unlawful. How About Yours?"

As already stated, good lenses and reflectors are now available, but a campaign of education is necessary to secure a better adjustment of head-lamps. I suggest that this is a movement that the Society can well sponsor and believe that, if one member in each section of the Country would be responsible personally for furthering

the movement, results would be secured quickly. The local automobile club, the dealers' association, the safety council and other civic bodies can work together with enforcement officers, and the results secured from this cooperation should provide a remedy for the present unsatisfactory conditions prevailing on the roads at night because of improper lighting.

QUESTION:—Would it not be possible to make lenses so that they would not turn in the lamp and get out of adjustment?

R. N. FALGE:—Notched lenses and other means are in use today on some cars to keep the lenses from rotating. Standards have been established for notches by the Society, and can be found in the S. A. E. HANDBOOK on p. B6.

QUESTION:—Instead of depending only on screens for adjustment, why not employ mechanical methods such as fixtures to set the lamp and the bulb?

MR. FALGE:—Attempts have been made to develop equipment of this kind but, so far as I know, none of these devices has come into general use. Devices could easily be made to adjust accurate equipment. The difficulty arises from the fact that commercial head-lamps are seldom accurate in the laboratory sense of the word, and it is very difficult to compensate in a focusing and aiming device for all of the little variations that may affect the adjustment.

QUESTION:—Could the lateral spread be obtained solely from a reflector with only a plain lens?

MR. FALGE:—Yes; that is being done in a number of makes of reflector on the market.

QUESTION:—Do you find that you are forced to dim with the compensating lens?

MR. FALGE:—At times, yes; particularly in some States where motorists are so used to seeing glaring head-lamps on approaching cars that they insist on dimming if they see a white light in the approaching head-lamps, regardless of whether they glare or not. In other States, like Massachusetts where head-lighting regulations are strictly enforced, dimming is illegal, and motorists do not signal to opposing drivers to dim unless their head-lamps are really glaring.

QUESTION:—Would it be practicable to compel motorists to have their lamps adjusted at authorized stations? What has been the experience in States where this has been attempted?

MR. FALGE:—State-authorized service-stations to compel motorists to adjust their head-lamps and keep them in adjustment seem to be working out very well in several States. Mr. Maples brought out the point that head-lamps at times are defective, and will not remain in adjustment over a reasonable period of time.

QUESTION:—How many accidents are due to dimming?

MR. FALGE:—The only statistics that I have on this subject are those furnished by Mr. Devine. He found, if I remember correctly, that about 25 per cent of the fatal accidents at night during 1921 were due to poor head-lighting.

MR. DEVINE:—We analyzed approximately 400 fatal accidents, for the reason that all fatal accidents involve a very complete investigation; we had all the facts at our finger tips. An analysis of these 400 cases shows that, of the night fatalities caused by lighting conditions, three were due to insufficient light to every one due to glare. We have gone into the matter of approved adjusters very thoroughly. We send an application form and instructions to anyone who wishes to be appointed as an approved adjuster and now have approximately 800 of them all over the State. We find that we could not get any enforcement without making use of them.

CHAIRMAN C. T. MYERS:—What reports do you get from those adjusters as to the faults of equipment?

MR. DEVINE:—We send out a notice to a man who has been complained of, stating that our office is in receipt of a complaint to the effect that his lights are adjusted improperly, that he has no device on, that he has an improper bulb or that his reflector is defective. He is notified either to fix the defect himself and report to one of our examination points, or go to an approved adjuster and have them fixed. At the bottom of the notice is a space for the adjuster to fill out and sign, stating that he has fixed the lamps and certifies that they comply with the law. The report, so returned, is filed with the complaint.

CHAIRMAN MYERS:—What kind of complaint with regard to equipment do you find comes in on these reports?

MR. DEVINE:—The commonest complaints are improper adjustment and defective reflectors. We have done considerable work with reflectors because we realize that, to get the required amount of light, the reflector must be in good condition. The average motorist does not appreciate how fast a reflector will deteriorate, particularly if the glass is broken and is left out for a day or two. A steel reflector, when silverplated, will be ruined in a short time if moisture gets on it.

MR. CARLSON:—Out of some 400 cars that were tested at the Bureau of Standards in the City of Washington, 36 per cent had the lenses twisted so that the beam was not horizontal, 73 per cent were out of focus and 47 per cent were not tilted correctly. A record was kept of the cars tested. If the head-lamps were in such poor condition that they could not be adjusted readily, the motorist was advised either to buy a new reflector or, in very bad cases, to get an entirely new outfit, reflector and device.

In some cases it is very difficult to tilt the lamp down because it is mounted rigidly on the fender. This difficulty usually can be remedied by buying new brackets that are slotted or, in the case of Ford cars, by using a wrench or tilting iron. The Lincoln car has a lever connected to the reflector that moves the beam up or down. Some cars have universal mountings so that, by loosening a nut, the whole head-lamp housing can be moved.

MR. DEVINE:—The question of adjustment and the simplicity of adjustment have been touched on in one respect or another by practically every speaker tonight. I have already told you just what happens the moment we stop enforcing the law; and that is not due to the fact that our adjusting instructions are complicated. We have abandoned the four focal adjustments that we had formerly; the principal, back, front and special. We have also stopped specifying the varying degrees of tilt that are necessary, 3 in. for one lens, horizontal for another and so on. All those things were misleading and made the instructions involved so that the motorist would give up in despair.

We now show two pictures on our instruction sheet: one, the beam from a typical lens properly focused and properly aimed, of the general elliptical shape shown by Mr. Falge, concentrated just below the horizontal; the other, a lamp out of focus with the beam spread all over the screen. We tell motorists to place the car 25 ft. from a wall, to move the focusing device until the beam looks like the illustration, and then to tip the lamp down until the top of the beam is a sufficient distance below the center of the lamp to allow for loading the car. That is all.

CHAIRMAN MYERS:—One point that has not been brought out is that persons who drive over asphalt or dark-surface roads are more apt to be serious offenders than those who drive over macadam or concrete roads, on which there are considerable reflection and illumination from a beam of given candlepower. We cannot ask lamp manufacturers or mirror manufacturers to compensate for that, but many things affect illumination besides manufacture and installation. Some persons insist on adjusting lamps so that they can drive over certain roads to their satisfaction. They may also have certain optical defects to which they cater.

Two important points are to be considered. First, that the motorist must be given a simple method of determining what is the proper sort of light and a simple method of getting it; second, that considerable refinement in the manufacture and assembling of lighting equipment used in automobiles is necessary.

A large number of parts having perceptible tolerances must be assembled and still preserve the alignment of the focus. This means that the tolerance in the various parts must be reduced considerably below that existing at present. That is a matter of hard plugging on the part of the manufacturer of the equipment and persistent educating on the part of the State departments that are entrusted with the making of the proper laws and the enforcing of them. All these forces can be brought into agreement. We must depend on individuals following up the points that have been brought out and bringing pressure to bear in the proper quarter.

MR. FALGE:—One point that should be mentioned is that the lens shown in the paper as designed to compensate for variations in filament positioning is one that we developed ourselves. We were interested not because we intended to market the lens, but because it appeared to offer a means, when used with fairly accurately assembled bulbs, to eliminate the focusing adjustment. We expect to turn it over to manufacturers of equipment of this character but hope at the same time to devise some means for encouraging its use with good reflectors and other light-redirecting parts. With poorly made equipment, its advantages in eliminating the need for a focusing adjustment and in distributing the light in a desirable manner will be lost to a large extent.

Another point that I believe is very important is that where but one type of light distribution is available, and that is supposed to be legal, the motorist is tempted to aim the beams a little too high to compensate for variations in the range due to loading and provide for the small percentage of time when he needs to see a greater distance ahead than is permitted with a strictly legal adjustment. By raising the beams slightly, he causes objectionable glare at all times. It does not seem at all unreasonable to suppose that, with tilting equipment, spotlights, or other means for adjusting the height of the beam, under the control of the driver, such temptation would not only be eliminated but the motorist would even be inclined to be overly decent and tilt the beams even more than is required by law. The glaring light must, of course, be eliminated in passing other cars and in the city, but no objection should be made to this, as the legal distribution would be entirely satisfactory for city driving and passing other cars in the country.

F. H. FORD:—If I disagree with some of the statements or ideas advanced in the paper, it is not because I do not appreciate the effort that Messrs. Falge and Brown have put forth in bringing the matter of good driving-light before all of us in a convincing and interesting way. It is because a candid discussion of the subjects covered in the paper will be likely to be of general good that I am bringing up some points of difference between my opinions and those of the authors of the paper. As stated in the paper, we are still struggling with the problem of poor driving-light and glare because the head-lamp question has not been "handled so effectively as have others of less importance that have to do merely with road performance and repair bills." Is it not possible that the answer to the whole problem is just there?

If we can talk to the driver in terms of what a good driving-light will do for him in the way of better road-performance and fewer accidents, will it not be much easier to wake him up to the importance of good driving-light than if we keep telling him about beam candlepower, eight-point tests, degrees of arc, focal points and police courts? If the illuminating engineers will devise some way of showing where the various head-lamp devices are supposed to put the light on the road and indicate the illumination at these points in terms of bright moonlight or some other unit of comparison with which we at least think we are familiar, the average driver probably will be able to get the idea. The lighting specifications of the Illuminating Engineering Society and the Society of Automotive Engineers were formulated for use as a guide to trained technicians in making laboratory tests. We have been trying to use them in getting the interest of the kindergarten class in illumination, and the only wonder is that we have succeeded as well as we have.

The mystery with which the subject of automobile headlighting is surrounded is well illustrated by the instructions that usually are furnished as a guide for installing and adjusting head-lamp devices. Even the authors seem to be somewhat doubtful about the instructions they have given in this paper. Quoting from it:

> Most of the readers of this paper who wish to improve the headlighting on their own cars, but do not know just how to go about it, will find the following procedure of adjustment fairly simple *after reading the discussion of the principles of headlighting equipment that have been stated in the paper.*

The italics are mine.

The great trouble with all of the instructions is that, unless a man knows enough about headlighting not to need any instructions, the instructions are likely to be more misleading than helpful. For instance, practically all of them start out by telling you to take the fronts and the lenses off your head-lamps. Then you are directed to adjust the position of the lamp in the reflector to give some kind of a round spot of light on a screen a certain distance in front of the head-lamps. Then you are told to put the head-lamp front in place on the head-lamp and to be careful when putting it on that you do not disturb the adjustment that has been made. The instructions given in this paper suggest that you can tell whether or not the adjustment has been disturbed by putting one front with its lens on the head-lamp, locking it in place as it will be used, and then holding the other front with its lens close to the reflector to see if the pattern of light is the same for both head-lamps. If the adjustment has not been disturbed, the patterns will be alike. If they are not alike, something has happened and you must guess what. There is, of course, always the chance that you have made the circle of light you adjust for originally of the wrong size when adjusting both head-lamps; and so, even if the pattern of light from the two head-lamps is the same, both are wrong.

It would simplify matters greatly if the manufacturers of head-lamp devices could be persuaded or compelled to

furnish a facsimile of the pattern of light thrown by their device when it is installed properly and the head-lamp is adjusted correctly for focus and tilt. If the pattern of light were shown in relation to a horizontal line representing the level of the center of the head-lamp, it would be necessary only to tell a person to adjust the position of the lamp to give the official pattern of light, with the head-lamp front and lens in place just as it would be used on the road. The head-lamp should then be pointed to bring the pattern of light in the same relation to a line representing the level of the center of the head-lamp as is shown on the official pattern of light for that particular device. How can we expect people to make a correct adjustment of head-lamps if they do not know what the light they are trying to adjust for looks like or what it is supposed to do?

Referring to the possibility of simplifying the matter of adjustment by omitting the focusing device, it seems doubtful if the benefits from such a procedure would be great enough to compensate for the drawbacks. First, it would require so much greater accuracy in the making and the assembly of the parts of the head-lamp that it would increase the cost considerably. Second, the adoption of a fixed focus would mean, of course, that only a device that was made for use with that particular focus could be used. It hardly seems that the art of head-lighting has advanced to a point which will permit us to say that any existing device represents the ultimate limit of perfection and that further development should be shut off by adopting a head-lamp construction that can be used only with one particular device. It would seem much better to make the focusing devices used as simple and substantial as is practicable and to design the light-directing devices themselves so that it will not be necessary to refocus when a new lamp is put in. This would avoid creating a patent monopoly or shutting off further development in the matter of headlighting.

From this paper, it would seem that even the apparently ideal lens described does not do away with the necessity for focusing where the center of the lamp filament is located more than 3/64 in. from the principal focus of the reflector. It would seem also that this is less than half the present tolerance of variation in the location of the filament field alone and allows nothing for variation in the other parts of the head-lamp or in the lens itself.

We cannot consider the question of headlighting purely from an engineering standpoint. Commercial questions involved must be given consideration. When considering any general changes in construction in the head-lamp, in the electric lamp that serves as a source of light or in some device used for redirecting the light from the head-lamp reflector, we must, before adopting such changes as standard, determine carefully whether such action will limit any of the units that make up the complete head-lamp to those of some type that is protected by patents to such an extent that its forced use would involve a considerable increase in the cost of the complete head-lamp.

It is pointed out in the paper that, when the lamp filament is located at the principal focus, the light from the reflector can be redistributed most effectively by vertical flutes in the cover glass to spread the beam laterally and variable horizontal prisms to bring the maximum candle-power near the top of the beam. This means that, if the principal focus were adopted as the only focus to be used, we should be compelled to make use of some ineffective means for redistributing the light or we should be obliged to make use of a construction that is advertised as being covered by a basic patent.

GENERAL DESIGN AND URBAN PERFORMANCE OF ELECTRIC TRUCKS

(*Concluded from p.* 30)

voltage, a better operating speed and a more uniform discharge-capacity than if the battery is used for less than its rated capacity.

MR. SEVERINS:—How much work is involved in changing the battery when the car is used for day-and-night service?

CHARLES NOVAK:—The average time required for changing the battery is 1 hr., but some do it in 30 min. using the old-style cradle.

R. H. MARRINER:—In the Exide garage in New York City we took care of a number of trucks of the Burns Coal Co. By using a Shepard hand-truck we changed batteries in from 5 to 10 min. after proper preparation. In other words, by placing the spare battery near the truck, spotting the car near that point and being properly prepared, two men could do the job in from 5 to 10 min. You must have a level floor and a special place in the garage for making the change.

P. M. HOLDSWORTH:—What type of interchange does Mr. Novak use? Is it the Stone cradle or something of that sort?

MR. NOVAK:—It is the common, ordinary delivery-truck such as Mandel Bros. have; no cradle at all. I never saw a man change a battery in 5 min.

MR. HOLDSWORTH:—You take out a single tray at a time?

MR. NOVAK:—Yes; there are eight changes.

MR. HOLDSWORTH:—It is not changed as a unit?

MR. NOVAK:—No.

MR. CARROLL:—In closing, I should like again to emphasize the fact that I have not intended to convey the impression that the electric truck is the modern cure-all for all transportation. There is not, in my opinion, any competition between the electric truck and the gasoline truck in the economic sense of the word, because each of these types has its particular field, which can be served best only by the type of truck suited to that field.

THE GENERAL-PURPOSE TRACTOR

BY "general-purpose tractor" is meant an efficient source of mechanical power that can be used not only for customary tractor drawbar and belt-operations, but also, when properly equipped and adjusted, for efficient cultivating and other light drawbar-work now done with horses.

Farm operations can be classified as follows: preparation of the seed-bed, planting the seed-bed, cultivating, harvesting, belt work and miscellaneous. Reference to average operations on the average farm indicate that horses are necessary for planting seed-beds, cultivating row crops, harvesting most of the crops except wheat and miscellaneous hauling. Tractors, as we know them today, are most suitable for the preparation of seed-beds, harvesting wheat and belt operations.

Yearly Operations on Average Tractor-Farm

The various operations performed each year on an average tractor-farm are listed below, and the usual source of power on efficient farms is specified.

Preparation of Seed-Bed in the Spring	
Plowing	Tractor
Discing	Tractor
Harrowing	Tractor
Planting the Seed-Bed	
Drilling Grain or Seed	Horse
Planting Grain or Seed	Horse
Planting Potatoes, etc.	Horse
Cultivating Row Crops	Horse
Harvesting All Crops	
Cutting Small Grain	Tractor or Horse
Mowing Hay	Horse
Loading Hay	Horse or Tractor
Cutting Corn	Horse
Digging Potatoes	Horse
Preparation of Seed-Bed in the Fall	
Plowing	Tractor
Discing	Tractor
Harrowing	Tractor
Belt Operations	
Threshing	Tractor
Silo Filling	Tractor
Feed Grinding	Gas Engine or Tractor
Wood Sawing	Gas Engine or Tractor
Baling	Tractor
Shelling	Tractor
Shredding	Tractor
Miscellaneous	
Orchard Spraying	Horse
Spreading Manure	Horse or Tractor
Hauling	Horse

An examination of several tractor investigations discloses the interesting fact that the present tractor-owner displaces on an average of only 2.8 horses per tractor. On many farms the maintaining of both a tractor and horses would be too big a burden. There is not sufficient work to justify buying a tractor for only a part of the farm work.

In the winter wheat-belt and prairie rice territories, tractors are used in great numbers, but in the corn and cotton States where cultivating and, to a lesser extent, other light drawbar operations play a more important part in farm management, fewer tractors relatively are found.

Diversified farming is highly recommended by most farm management authorities, yet diversified farming means more cultivation and more light drawbar-work, for which the present tractor is unsuitable.

The importance of row crops can be appreciated by referring to the statistics of the major crops grown in the United States, as published in the 1922 Yearbook of the Department of Agriculture. In connection with these figures, which are presented in Table 1, it should be noted that the statistics of soy-beans and cow-beans have been omitted, as they are planted both broadcast and in rows.

TABLE 1—ACREAGE AND VALUE OF GRAIN AND ROW CROPS

	Acreage	Value[1]
Grain Crops		
Wheat	61,230,000	$864,139,000
Oats	40,693,000	478,548,000
Barley	7,390,000	97,751,000
Rye	6,210,000	66,085,000
Flax	1,308,000	25,869,000
Rice	1,055,000	39,178,000
Buckwheat	785,000	13,312,000
Total for Grain Crops	118,671,000	$1,584,882,000
Row Crops		
Corn	102,428,000	$1,900,287,000
Cotton	33,742,000	1,192,461,000
Grain Sorghums	5,051,000	79,389,000
Potatoes	4,331,000	262,608,000
Tobacco	1,725,000	306,179,000
Sweet Potatoes	1,116,000	84,492,000
Sugar Beets[2]	606,000	.....
Sugar Beets[3]	537,000	29,605,000
Cane	521,000	.....
Broom Corn	.....	7,614,000
Total for Row Crops	149,451,000	$3,862,635,000

[1] The values given are based on the prices current on Dec. 1, 1922.
[2] Area planted.
[3] Area harvested.

In 1922 the row crops mentioned occupied 30,780,000 acres more than did grain crops. Further explanation of the pressing need for a good general-purpose tractor seems unnecessary.

Motor-cultivators have been efficient but lacking in power. With plowing attachments, they seem to be deficient in adaptability, durability or dependability, economy and ease of handling.

Plowing and cultivating are two of the big jobs on the farm. Power is needed for plowing; speed for cultivating. To be thoroughly practical a general-purpose tractor must be efficient for both classes of work. A one-plow tractor has not sufficient power to pull a two-row cultivator. The additional power and weight necessary for pulling two plows will not be found harmful or too expensive in cultivating.

In the next few years the two-plow or the three-plow tractor will increase in number, but the general-purpose tractor will then come into its own. One expert expresses the opinion that the main development will be a general-purpose machine that can be used in nearly all farm operations. While the present type of tractor can be regarded as a successful field-machine, so far as plowing and general operations of that nature are concerned, it is far from satisfactory for other field operations.

Row-crop farming lacks in efficiency because suitable mechanical power in the form of a general-purpose tractor is not available. Labor conditions on the farm are such that extra help for cultivating and harvesting, which usually overlap, is expensive and hard to get. A general-purpose tractor will relieve this situation. In designing a general-purpose tractor, plowing and belt-work should be kept in mind as well as cultivating and mowing. The general-purpose tractor should be able to pull two 14-in. bottoms under most conditions, operate a 20 or 22-in. thresher, mow a 6, 7 or 8-in. swath or pull two mowers if desired and plant and cultivate two or three rows at a time.—From a paper by F. A. Wirt of the J. I. Case Threshing Machine Co., presented before American Society of Agricultural Engineers.

Standards Committee Division Reports

IT must be with great satisfaction that members of the Society note the effects of its early entry into, and the vigorous pursuit of, the problems of standardization. Many, who, at the beginning, were fearful of the consequences of too aggressive work in what was then a relatively pioneer field, are now enthusiastic over the practical value of sensible standardization. Society members can review with pride a long list of accomplishments and, further, can note the following standards under consideration.

In the development of each of these standards, intensive and minute review by able men is necessary and brings forth every detail of their requirements with respect to material, design, manufacture, distribution, sale and service insofar as each of these items applies. This review further lays bare the basis for fundamental as well as necessary sensible research.

Standardization automatically creates the highest sensible type of engineering product to meet the requirements. Serious errors resulting from the correct use of such products are practically impossible.

In the development of a standardization scheme for almost any industry producing machines, one logical procedure consists of two important steps: First, the elimination of needless varieties and types and of illogical sizes; and, second, the development of suitable standards. Most standards fall naturally into the following groups:

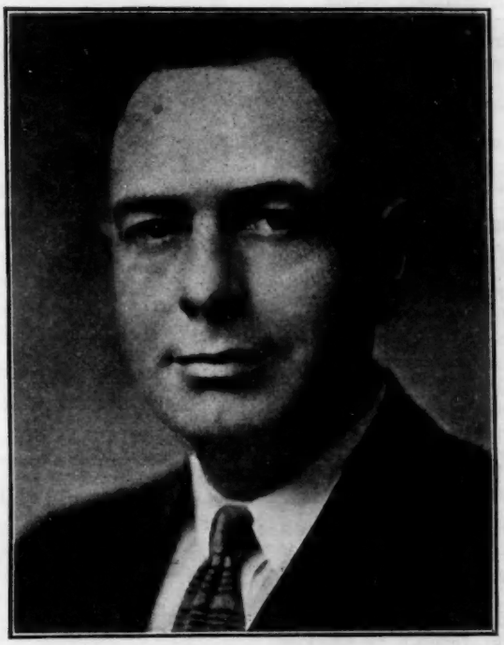
(1) Nomenclature
(2) Materials standards
(3) Manufacturing standards
(4) Design standards
(5) Machine elements, parts and fittings
(6) Machine-unit standards
(7) Complete machine standards
(8) Special equipment and attachment standards
(9) Research, testing, reports and analysis

Under the heading of nomenclature is included all that relates to correct naming and terminology.

STANDARDS COMMITTEE action toward approving the accompanying Division Reports will be taken at the Annual Meeting on Tuesday, Jan. 22, in the Meeting Hall on the 15th floor of the General Motors Building, Detroit. The reports are published in this issue of THE JOURNAL in order that those interested may have sufficient time to study the recommendations prior to the Standards Committee Meeting. This meeting will be in the nature of a public hearing.

Non-members of the Standards Committee or of the Society will be welcome at the Standards Committee Meeting and their comments on the Division recommendations will be carefully considered.

Special attention is called to the introduction by E. A. Johnston, chairman of the Standards Committee. This outlines a logical procedure that could well be followed in either company or general industrial standardization.



E. A. JOHNSTON

Materials standards include specifications that relate to selective uses, analyses, physical properties, tolerances and the like.

In the third group, manufacturing standards, is included everything that relates to processes and procedure in turning out uniform products in large quantities.

The fourth group of design standards covers those that relate to types, features, practices, procedure, data and all creative products.

In the next group those standards of the most elemental features of a group of machines that may have distinctive features according to the fields being served are included.

The machine-unit standards relate to those groups of parts that work together or can be used here and there in several complete machines.

Under the heading of complete-machine standards are included those that give distinction to the company putting them out or that evidence suitability for the purpose for which they were created.

The standards included in the special equipment and attachment group relate to those parts that add to general usefulness, refinement or the adaptability of the outfit to various conditions.

In the ninth and last group are included standards of research, methods of tests, standardized reports and all such activities as relate to the analysis of the characteristics of the product as well as what relates to the determination of unknown data.

If now we apply to each object of standardization what may be included under each of these nine headings, as well as their natural subdivisions, we will have a comprehensive and logical analysis.

The creation of standards should be satisfying to all committee-men who have worked upon them because the results are of real consequence and value. The industry as a whole should further support their efforts.

In this important standards work it has been a great pleasure to enter into the problems

with these earnest engineers whose generosity in time, frank discussions of the problems involved and energy and skill displayed in the advancement of this professional work have been inspiring, and from it all I have gained much.

E. A. JOHNSTON,
Standards Committee Chairman.

AGRICULTURAL POWER-EQUIPMENT DIVISION REPORT

At the June meeting of the Standards Committee the Agricultural Power-Equipment Division proposed for adoption as S.A.E. Recommended Practice specifications for tractor canvas and rubber endless driving-belts developed by the Subdivision on Tractor Belts and Pulleys. The accompanying specifications for tractor leather driving-belts were developed by the same Subdivision, of which O. B. Zimmerman, of the International Harvester Co., is chairman, and were approved by letter-ballot by the Division.

It is believed that the present recommended practice for canvas and rubber belts and the proposed specifications for leather belts will find extended use in other applications than tractor drives.

The principal reason for developing specifications for the three types of belt is to meet all possible field conditions. The relative value of the different types of belt as to adhesion, carrying load per square inch of cross-section and the ability to splice when necessary, as well as the ability to be made waterproof, has been given much consideration by the manufacturers and their best minimum practice is reflected in these specifications.

Proposed S. A. E. Recommended Practice for Tractor Leather Driving Belts

For farm tractors, new endless leather belts shall measure the full taped and specified length without allowance being made for the splice. This length shall be the single stock length and correct to within a tolerance of plus or minus 0.5 per cent to take care of reasonable shrinkage or stretching and splicing in manufacture.

DIMENSIONS AND RATINGS OF LEATHER BELTS

Belt Width, In.	Belt Length, Ft. Plus or Minus 0.50 Per Cent	Approximate Horsepower Rating	
		Single Ply	Double Ply
3	60, 75	15	24
4	60, 75	21	34
5	60, 75	25	40
6	60, 75	30	48

The horsepower rating is for 16-oz. heavy-weight belts. For ratings of medium-weight belts, multiply by 0.9. The horsepower ratio of single to two-ply belts is 1.6.

The approximate horsepower rating is based on a belt speed of 3000 ft. per min. Belts shall be operated at one of the S. A. E. Standard belt speeds and at the above ratings. Belts are subject to a reasonable initial tension. The rating is such as will enable these belts to carry from 50 to 100-per cent overload according to weight as shown below over a reasonable period and during emergencies without injury.

PULLEY DIAMETERS

The driven pulley diameters shall be not less than 7 in. for light, 8½ in. for medium and 10 in. for heavy belts and should be preferably as large as practical conditions permit.

To insure good traction and long life, thinner and wider belts should be chosen in preference to thicker and narrower belts.

SPECIFICATIONS

Leather.—Belts under these specifications shall be made from vegetable-tanned belting butts only of standard tannages. They shall not be rolled. They shall be waterproof.

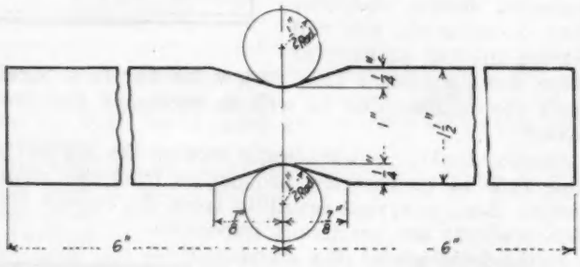
Currying.—The leather shall be properly curried. The grain surface shall be worked smooth but without rolling. The belt shall be dressed with a good waterproof dressing. The grease-content shall not exceed 25 per cent of the dry weight of the leather and shall not contain more than 35 per cent of unsaponifiable matter.

Adulteration.—Magnesium sulphate, glucose, barium chloride or any other materials shall not be used for weighting the leather. The presence of a greater amount of stuffing content than hereinafter specified shall be considered as adulteration.

The belting shall be obtained from selected side-stock, and from within a distance of 24 in. from the backbone, thus excluding all belly and flank stock. No piece of leather in the finished belt shall be more than 56 in. in length.

Tensile Strength.—Five samples taken from one belt or one lot of belts shall average 3300 lb. per sq. in. of cross-section, and the minimum shall be 3000 lb. per sq. in. The average shall be determined with five test-specimens selected at random from different parts of the sample being examined.

Test specimens as shown in the accompanying illustration shall be cut with a metal die. The edges of the test-specimen shall be a cut at a true right angle to the surface. The minimum thickness inside the gage marks shall be used in determining the area of the cross-section of the test-specimen.



TEST-SPECIMEN USED IN MAKING TENSILE-STRENGTH TESTS

Stretching.—All leather after stuffing shall be thoroughly stretched while wet and left under tension until dry. All belt pieces shall have the stretcher-marks cut off.

The average elongation at a tensile stress of 2000 lb. per sq. in. shall not exceed 16 per cent. The average shall be determined with the same five test-specimens used for determining the tensile-strength, the data being taken at the same time.

To determine the amount of elongation parallel gage-marks 2 in. apart shall be placed upon the restricted portion of the test-specimens. The distance between the gage-marks shall be measured with a pair of spring-dividers, at a tensile stress of 2000 lb. per sq. in.

LENGTH OF LAPS IN INCHES

Ply	Thickness, In.	Belt Width, In.	Minimum Lap, In.
Single	19/64 and over	3	4
		4	4
		5	5
		6	6
Two-ply	16/64 and over	3, 6	3

The amount of stretch shall then be determined by measuring the opening of the dividers on a scale.

Laps.—The length of laps shall be made with the limits given in the table at the bottom of p. 38.

The laps shall not open when subjected to a tensile stress of 2000 lb. per sq. in. The opening of the laps shall be determined by testing two specimens cut across the point of the lap lengthwise of the sample. The laps are to be carefully cemented with waterproof cement and may be tested by immersion in water for 24 hr.

Weight and Thickness.—The thickness for the different grades of belting shall be as specified in the accompanying table.

AVERAGE THICKNESS OF DIFFERENT GRADES

Grade	Weight, Oz.	Average Thickness, In.
Medium single-ply	14	10/64 up to 12/64
Heavy single-ply	16	13/64 up to 14/64
Medium two-ply	21	16/64 and over

The average thickness shall be determined by measuring the thickness of 15 to 20 plies of the belt when rolled, and dividing this value by the number of plies measured.

Uniformity.—No point in any belt shall be more than 2/64 in. thicker, nor more than 2/64 in. thinner, than the average thickness.

Tolerances.—Belts shall not vary from nominal width more than 2½ per cent.

C. B. ROSE, Chairman.

AXLE AND WHEELS DIVISION REPORT

C. C. CARLTON

Since the Standards Committee Meeting at Spring Lake, the Axle and Wheels Division has held only one meeting, but considerable work has been accomplished by the Subdivisions. Probably our most important work is being carried on by the Subdivision on Differentials, of which S. O. White, of the Warner Gear Co., is chairman. Mr. White recently made a report covering four-pinion differentials with the side-gears mounted either in the case or in the spider, which, if adopted, will greatly simplify the problems of the differential manufacturers who are now obliged to produce a large number of designs differing only in unimportant details. [The report of the Subdivision on Differentials is printed in this issue under Tentative Standardization Work on p. 74.] W. W. Davison, of the Wire Wheel Corporation of America, is formulating, in cooperation with the manufacturers, specifications for wire-wheel spokes.

BRAKE-DRUMS

The standardization of brake-drums was undertaken first by the Truck Division in 1920, a Subdivision being appointed with R. J. Burrows, of the Clark Equipment Co., as chairman. A report was drawn up at that time and referred to the brake-drum manufacturers and users but, owing to the differences of opinion that existed, no definite action was taken. Upon the appointment of the Axle and Wheels Division the subject was referred to this Division.

Early last year we sent out a general letter to the passenger-car and the motor-truck builders requesting definite information as to the desirability and the feasibility of standardizing brake-drums. As the consensus of opinion brought out by this general letter indicated that passenger-car brake-drum standardization is important and that standards should be developed, a Subdivision was appointed with E. R. Jacobi, of the Hayes Wheel Co., as chairman, the other members being

F. C. Burkhardt	Crosby Co.
R. J. Burrows	Clark Equipment Co.
L. J. Fralick	Parish & Bingham Corporation
G. W. Harper	Columbia Axle Co.
J. S. Schneider	Bossert Corporation
A. Van Halteren	Motor Wheel Corporation
G. L. White	Federal Pressed Steel Co.

At the October meeting of the Division the Subdivision submitted the accompanying recommendations, which met with general approval of the Division members, although it was thought by some that definite wall-heights should be specified. The process of manufacturing is, however, such that it makes little difference whether there are variations in the wall-height provided there is a definite maximum. As some confusion exists as to the relation between the run-out and the eccentricity, the Division appended to the report a note on this point. It was also thought necessary to explain the manner in which the eccentricity should be measured.

The present trend is toward heavier steel for all sizes of brake-drum, but the proposed recommended practice is a big step forward in standardization, and the steel thickness can readily be revised as soon as practice indicates the desirability.

The Division recommends that the accompanying dimensions for passenger-car brake-drums be adopted as S. A. E. Recommended Practice.

Passenger-Car Brake-Drum Dimensions Proposed as S. A. E. Recommended Practice

No.	Outside Diameter	Inside Diameter	Stock Thickness	Maximum Height of Wall	Maximum Eccentricity[1]
0	8 11/64	8.005– 7.995	0.1250	1 1/16	0.010
1	10	9.790– 9.770	0.1250	1⅝	0.010
2	11	10.710–10.690	0.1650	2½	0.010
3	12	11.666–11.646	0.1875	2½	0.010
4	13	12.666–12.646	0.1875	2½	0.010
5	14	13.635–13.615	0.2030	2¾	0.010
6	15	14.635–14.615	0.2030	3	0.010
7	16	15.605–15.585	0.2180	3½	0.015
8	17	16.541–16.521	0.2500	3½	0.015

[1] Dimensions in inches.

The eccentricity shall be measured on the outside diameter ½ to ¾ in. from the outer edge of the brake-drum when it is mounted on a face-plate and registered from the center bore. (The run-out as measured by an indicator will be twice the eccentricity specified.)

FRONT-AXLE MOUNTINGS

At the October meeting of the Axle and Wheels Division the Division report that was referred back for further con-

sideration at the Standards Committee Meeting at Spring Lake was reviewed. The principal objection to the Spring Lake proposal was that it specified 12 instead of 8 bolts for hubs No. R1 to R4.

We recognize that usual practice has been 8 or even 6 instead of 12 hub-bolts and that the standard should follow current practice providing it is based on sound engineering practice. We still feel that 12 hub-bolts are not only ideal but desirable, and with the wider use of four-wheel brakes some engineers, who opposed 12 bolts at the Spring Lake Meeting, are now actually using 12 on both front and rear wheels with boss-spoke bolts omitted. We believe it best to adopt current practice now, but with the belief that 12 bolts will ultimately prevail.

We have also learned that the present S. A. E. Recommended Practice should be revised in view of the use of softer steel for the wheel hub. Under the condition, more metal is needed to back up the outer bearings. This can be obtained only by increasing the hub bores.

Data on the present practice for hub-cap threads have been compiled and a report to be based thereon is now being prepared by A. S. Van Halteren and R. J. Burrows. The Division recommends that the present S. A.E. Recommended Practice for Front-Axle Hubs, p. F1b, be revised and extended to conform to the dimensions given in the accompanying table.

Proposed Dimensions for Passenger-Car Front-Wheel Hubs

Hub Size	Bolt-Circle Diameter, In.	Number of Bolts	Bolt Diameter, In.	Hub Bore for Outer Bearing	
				Maximum	Minimum
R0	5	6	3/8	.....	.....
R1	5 3/4	8	7/16	2.2380	2.2370
R2	6	8	7/16	2.2380	2.2370
R3	6 1/4	12	7/16	2.6135	2.6120
R4	6 1/4	12	7/16	.....	.....

Felloe-Bands

Among the subjects referred to the Division by the Council, as a result of limiting the scope of the Tire and Rim Division's work to tire and rim matters only, is felloe-bands. At the meeting of the Tire and Rim Association of America held on Oct. 9 it was requested that the Society consider changing the present tolerances of plus 0 and minus 1/16 in., specified in the present S. A.E. Standard for Felloe-Bands, p. G7 of the S. A. E. Handbook, to plus 1/16 in. and minus 0, before application to the wheel, so that the manufacturers can more easily hold to the S.A.E. tolerances of plus 1/16 in. and minus 1/32 in. for the band circumference after application. The revision meets with the general approval of the Division members as it does not affect the tolerances for the circumference of the finished wheel.

Proposed Change in Felloe-Band Tolerances

The present S. A. E. Standard for felloe-bands should be revised to specify tolerances of plus 1/16 in. and minus 0, instead of plus 0 and minus 1/16 in., for the felloe-band circumference before application to the wheel.

C. C. Carlton, Chairman.

FRAMES DIVISION REPORT

The two dimensions that lend themselves most favorably to standardization are the frame width and the nominal frame-depth without regard to thickness of material. By assuming a nominal frame-depth and not specifying the stock thickness, the thickness may be varied to meet the individual conditions such as the wheelbase and the character of the load. In other words, while the outside depth of the channel may vary according to the thickness of stock, the inside dimensions will remain the same, and this is the important point in the fabrication of side-rails.

The accompanying recommendation of the Division was formulated at a joint meeting of the Frames and the Truck Divisions in March of last year. As a result of circularizing it among truck and frame builders for comment, certain changes were made. The revised recommendation was published in the December, 1923, issue of The Journal on p. 503.

It is argued that to classify frames on a basis of capacity rating is meaningless. This point is well taken. However, if a builder should feel that the proposed design for a certain capacity of truck is either too light or too heavy for his particular design, there should be no objection to using either the lighter or the heavier section.

The standardization of frame widths would be of greater benefit to the industry as a whole than any other dimension. At present a great variation exists in practice. However, it is felt that the proposed standards agree with the practice of the majority of the builders and could be adopted greatly to their benefit in future designs.

Proposed S.A.E. Recommended Practice for Motor-Truck Frames

Truck Capacity, Tons	Frame Width, In.			Nominal Side-Rail Depth, In.	Actual Side-Rail Depth, In.
	Straight	Offset			
		Front	Rear		
Speed Wagons.....	32	....	....	5	4 5/8
3/4 to 1 1/2	34	31	34	6	5 1/2
2 to 2 1/2	34	31	34	7	6 1/2
3 to 3 1/2	38	....	....	8	7 1/2
Over 3 1/2	38	....	....	9	8 1/2

W. A. McKinley, Chairman.

ENGINE DIVISION REPORT

J. B. Fisher

In addition to the recommendations that the Engine Division is ready to submit for Standards Committee action, we have been working on the standardization of poppet valves and starting-cranks. Owing to changes in company connections it has been necessary to reappoint the Subdivision on poppet valves. Although this will delay the work, we should have a report ready for final action at the Semi-Annual Meeting. F. S. Evelyn, of the Continental Motor Co., has been working for some time on standardization connected with starting-cranks. The present S. A. E. Standard is limited to the starting-crank only, but there is a demand for standardization of the starting-crank lugs and of the crankshaft jaws that are often an integral part of the crankshaft.

The Division has been cooperating with the Passenger-Car Division, the Underwriters Laboratories and the National Automobile Chamber of Commerce in developing a method of numbering engines to minimize the theft of cars. Worthwhile ideas submitted to the Society as a result of publicity sent out by the Society office last year were incorporated in

actual samples that were submitted to the Underwriters Laboratories for test, but none was approved. A method of engraving the engine and the frame numbers was brought to the attention of the Underwriters Laboratories as a result of the publicity, however, and has been approved. The Division has recommended that the National Automobile Chamber of Commerce adopt this method as being the only one approved by the Underwriters Laboratories in accordance with the requirements of the Underwriters' Conference toward establishing a 7-per cent reduction in theft-insurance premiums where an approved system is used only on the engine or the car frame, or a 20-per cent reduction in such premiums when the system is used on both the engine and the car frame. This recommendation has been concurred in by the Passenger-Car Division.

Engine Testing Forms

It will be remembered that at the Standards Committee Meeting in January, 1922, and again in June, 1923, we proposed certain revisions in the present S. A. E. Engine Testing Forms, these proposals being referred back to the Division as a result of criticisms and suggestions. At our meeting in Chicago last October we carefully reviewed the previous proposals and the accompanying proposed revisions in the Engine Testing Forms were approved.

Proposed Changes in the S.A.E. Standard Engine Testing Forms

RULES AND DIRECTION SHEET

The following sentence should be inserted at the end of the fourth paragraph of the rules and directions for the use of the specification sheet:

> Give the diameter of the fan, the projected width of the fan blades and the ratio of the fan speed to the engine speed.

The last sentence of Item 32, reading, "State name and grade of oil used," should be omitted as it will be covered in the Log Sheet.

The following should be included as the last sentence of the rules and directions for the use of the specification sheet.

> (33) Give list and description of accessories attached to the engine during the test.

The following should be inserted at the end of the "Rules and Directions for Use of Forms":

CORRECTION FORMULA

$$B\text{-}Hp_c = B\text{-}Hp_o \times (P_s/P_o) \times \sqrt{(T_o/T_s)}$$

where

$B\text{-}Hp_c$ = correct brake-horsepower
$B\text{-}Hp_o$ = observed brake-horsepower
P_o = observed barometric pressure in inches of mercury.
P_s = standard barometric pressure in inches of mercury.
T_o = observed absolute temperature in degrees fahrenheit
T_s = standard absolute temperature in degrees fahrenheit

SPECIFICATION SHEET

Under Item 6 spaces should be included for the diameter of the fan, the number and projected width of the blades and the ratio of the fan speed to the engine speed.

At the end of the sheet the center-heading "Accessories" followed by the item "(33) Accessories Attached During Test" should be added.

LOG SHEET

The spaces for recording the name of the laboratory, the date and the names of the observers should be transferred from the right-hand to the left-hand side of the box at the top of the sheet.

Spaces at the right-hand side of the box at the top of the sheet should be inserted for recording the kind of oil, the grade, the cold-test and the Saybolt universal viscosity, at 100 and at 210 deg. fahr.

The following footnote should be added:

> If readings are corrected to 60 deg. fahr. and a barometric pressure of 29.92 in. of mercury, use the correction formula on Sheet A, Rules and Directions.

CURVE SHEET

The ordinates for the fuel consumption in pounds per brake horsepower hour should be changed so that 0.5 lb. per b.hp-hr. will be on the second line from the bottom of the sheet, the ordinates increasing by increments of the 0.1 lb. per b.hp-hr. up to and including 2.0 lb. per b.hp-hr. for every five lines.

The intermediate values for the brake-horsepower ordinates should be inserted.

Flywheel Housings

As a result of difficulty experienced in aligning the clutch-housing flange holes with the tapped holes in the flywheel-housing flange so that the capscrews can be started properly, we have given careful consideration to the correct size of the clutch-housing flange holes. A survey of present practice showed that out of 29 installations a clearance of 1/64 in. between the flywheel-housing flange capscrews and the clutch-housing flange holes was used by 4 companies, 1/32 in. by 22 companies and 1/16 in. by 2 companies. The recommendation of 12 of these companies was to adopt 1/32 in. as standard, but 2 desired 3/64 in. and 13 1/16 in.

Although the capscrews are not used for aligning purposes inasmuch as the clutch-housing flange has a pilot fitting into the flywheel housing, we feel that it would be inadvisable to recommend a greater clearance over the nominal bolt-size than 1/32 in. because if the holes are made larger than 1/32 in., very little bearing surface is left for the head of the capscrews.

The present standard does not specify fixed dimensions for the No. 5 flywheel housing. As there is a noticeable tendency in engine design toward smaller engines, we have specified eight 3/8-in.—16 U. S. S. tapped holes.

We have found that unless the various dimensions specified in the present standards are kept within certain limits, excessive misalignment or eccentricity results. We therefore consider it advisable to specify tolerances for the flywheel housing and the clutch-housing flanges, the face of the flywheel and the bore for the pilot bearing.

We are now considering the advisability of standardizing dimensions for plain crankshaft pilot bearings for transmission shafts inasmuch as this type of bearing is being used to a larger extent than formerly. No action is to be taken, however, until complete information as to present practice has been obtained and tabulated.

Proposed Tolerances for S.A.E. Standard Flywheel Housings

The bolt-holes in the clutch housing flanges should be 1/32 in. larger than the nominal diameter of the flywheel housing bolts.

The No. 5 flywheel housing should have eight ⅜-in-16 U. S. S. flange holes equally spaced on the 12⅝-in. bolt-circle, the holes nearest the vertical center-line being 22½ deg. therefrom.

The tolerances for the flywheel housing bore should be plus 0.005 in. and minus 0.000 and the maximum eccentricity 0.005 in. (Indicator reading, 0.010 in.)

The maximum variation of the face of the flywheel housing flange from its true position, when the housing is rotated on its axis, should be 0.003 in. (Indicator reading, 0.006 in.)

The maximum variation of the counterbored surface of the disc-clutch type of flywheel from its true position, when the flywheel is rotated on its axis, should be 0.0025 in. when measured at a radius of 5½ in. (Indicator reading, 0.0050 in.)

The maximum eccentricity for the 11½-in. counter-

bore in the disc-clutch type of flywheel should be 0.0025 in. (Indicator reading, 0.0050 in.)

The eccentricity for the bore in the disc-clutch type of flywheel for the pilot bearing should be 0.0025 in. (Indicator reading, 0.0050 in.)

The diameter of the pilot on the flange of the clutch housing shall be the same as the nominal diameter of the bore in the flywheel housing; the tolerances should be plus 0.0000 and minus 0.0050 in.; and the maximum eccentricity should be 0.0025 in. (Indicator reading, 0.0050 in.)

The maximum variation of the face of the clutch housing flange from its true position, when rotated about its axis, should be 0.0025 in. (Indicator reading, 0.0050 in.)

Engine Support Arms

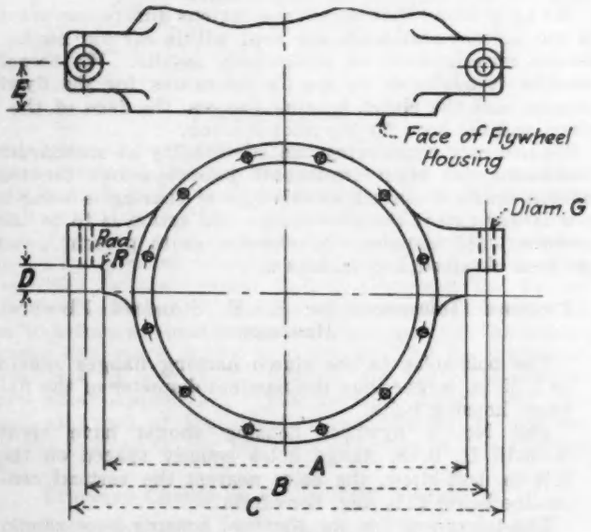
Early this year it was suggested that the Engine Division should standardize the position of the engine rear support-arms with regard to the face of the flywheel housing for each standard size. Information was obtained as to general practice, but as a result of subsequent suggestions the scope of the project was extended to include dimensions for the engine rear support-arms similar to the present S. A. E. Standard for truck and tractor engine support-arms.

Present practice was found to have crystallized to a large extent for certain of the dimensions, especially the center-to-center distance of the support-arm holes, the vertical distance from the support arms to the center-line of the crankshaft and the bolt diameter. However, the dimension which the Division was originally asked to standardize, the distance from the face of the flywheel housing to the engine support-arm holes, was found to vary greatly. In 64 engine installations, 32 different dimensions were used, not more than one dimension being used in six installations.

In submitting this report, we have considered it advisable to combine the present standard for truck and tractor engine support-arms with the proposed standard for the passenger-car engine support-arms. The adoption in actual practice of this standard will reduce the number of mounting brackets necessary and secure greater interchangeability of the various makes of engine.

J. B. Fisher, Chairman.

Revised and Extended S.A.E. Standard Proposed for Engine Rear Support Arms



Size No.	A	B	C	D	E	G	R Maximum
1	23½	26¾	28¾	2	3	25/32	7/16
2	23½	26¾	28¾	2½	3	25/32	5/16
3	23½	24½	25¾	2½	3	21/32	¼
4	23½	24½	25¾	2½	3	21/32	¼
5	23½	24½	25¾	2½	3	21/32	¼
2T[2]	20.000	21¾	23½	3	3	21/32	¼

[2]This size is intended primarily for tractors.

LUBRICANTS DIVISION REPORT

H. C. Mougey

The subject of transmission lubricants has been under investigation since 1920 by the Lubricants Division and by a Subdivision on Transmission Lubricants consisting of W. E. Jominy, of the University of Michigan, and H. G. Smith, of the Bureau of Standards. Tentative specifications have been submitted, published in The Journal, and circularized among automobile builders several times. The early report of the Subdivision covered the same two grades that are covered in the final Subdivision report that was recently submitted by Chairman Jominy.

The result of the publicity given these specifications has been to make small changes in the pour test in both the summer and the winter grades and in the flash test for the winter grade. The final report submitted by the Subdivision appeared to be in accord with desirable practice, except that it did not include a specification equivalent to a winter lubricant with a viscosity of 80 to 100 sec. at 210 deg. fahr., as desired by the General Motors Corporation.

The members of the Lubricants Division considered it advisable to include in the report the specification for the grade desired by the General Motors Corporation. The definite specifications proposed by the Division are given in the accompanying table.

Proposed S.A.E. Standard for Transmission Lubricating Oils

General.—These specifications cover grades of petroleum oil suitable for the lubrication of transmission and differential gears, worm drives, and roller and ball bearings used in connection therewith.

Compounded lubricating oils containing products other than those derived from petroleum are not dealt with in these specifications.

Specification No.	Grade	Minimum Flash-Point, Deg. Fahr.[3]	Viscosity, Saybolt Universal, at 210 Deg. Fahr., Sec.		Maximum Pour-Test, Deg. Fahr. (American Society for Testing Materials Method)
			Minimum	Maximum	
90	Special Winter	325	80	100	10
110	Winter	325	100	120	15
160	Summer	450	150	170	55

[3]American Society for Testing Materials Cleveland Open Cup Test.

H. C. Mougey, Chairman.

MOTORBOAT DIVISION REPORT

Since the initial meeting of the Motorboat Division in September, at which it was the consensus of opinion that there existed a real need for standardization in the motorboat

industry and that a determined effort should be made to develop standards, several meetings have been held and considerable progress has been made. The most important subject under consideration is, perhaps, the standardization of engine bed-timbers, the purpose being to make it possible for boat builders to design the engine bed-timbers so that engines of different horsepower or make can be replaced without expensive alterations in the bed-timbers. Other subjects under consideration are manifold connections, tachometer drives, stuffing-boxes and engine couplings.

The work on engine couplings involves a revision of the present S.A.E. Standard for motorboat engine couplings, steel and cast-iron couplings, propeller-shaft couplings and propeller mounts, pp. E7 to E18 inclusive of the S.A.E. HANDBOOK. The Division therefore recommends that the present standards for these parts be withdrawn from the S.A.E. HANDBOOK.

NON-FERROUS METALS DIVISION REPORT

ZAY JEFFRIES

At the beginning of the year considerable discussion was had regarding the specifications on white bearing metals, especially babbitt specifications Nos. 10 and 11, p. D103 of the S.A.E. HANDBOOK. Two points were under discussion: The limits of composition, which were thought by some to be too close, and the methods of sampling both ingots and cast products. The revised specifications of August, 1922, were finally adjudged satisfactory to all concerned as regards the composition limits. In reference to the methods of sampling, decision was made that the Division would not recommend any methods, this being in line with past decisions of the Division on the same subject.

Criticisms of Specification No. 78, Aluminum Sheet and Strip, were received to the effect that the "temper" designations given did not correspond to the commercial designations. It was decided to revise this specification in part to comply with this criticism. At the same time the properties of one additional "temper" were added to the specification and more detailed information was added on the permissible dimensional tolerances. Some changes were made also in the tensile-strength and elongation values of the various tempers of aluminum sheet, these changes being in line with the most uptodate information on this subject. The revised Specification No. 78 in its proposed final form, with the exception of a few minor points in connection with the interpretation of "tempers," was published on p. 418 of the November, 1923, issue of THE JOURNAL.

Proposed Revision of Specification No. 78 for Aluminum Sheet and Strip

Composition in Percentage.—Aluminum, min., 99.00.

Physical Properties.—Aluminum sheet or strip is furnished in several tempers or degrees of hardness. These tempers or degrees of hardness are indicated by the reduction in thickness produced by cold-rolling after annealing and are expressed in terms of the number of American wire (Brown & Sharpe) gage sizes included between the final annealing thickness and the finish thickness. Thus, temper No. 4 indicates that the sheet was given its final annealing at a thickness four gage-numbers thicker than the finish gage, to which it was subsequently reduced by cold-rolling. "Temper No. 0" indicates that the sheet or strip is in the soft annealed state. "Hard temper" indicates that the sheet or strip has been reduced in thickness after its final annealing by 12 or more gage-numbers by cold-rolling. The mechanical properties of aluminum sheet or strip of tempers Nos. 0, 4 and 6 and hard temper are given in the accompanying table.

The tensile test-specimen shall be cut from the sheet or strip parallel to the direction of rolling. The bend test-specimen may be cut without regard to the direction of rolling. Sheet or strip of tempers Nos. 0 and 4 shall withstand being bent-cold flat upon itself, without cracking. Although tensile tests of sheet or strip of temper No. 6 indicate an elongation only slightly greater than that of the hard-temper sheet, it is considerably more ductile, as is evidenced by the fact that it will withstand cold-bending through an angle of 180 deg. around a diameter equal to twice the thickness of the sheet, without cracking. Hard aluminum sheet or strip will not endure any considerable amount of bending without cracking, especially in the thicker gages.

PHYSICAL PROPERTIES OF ALUMINUM SHEET AND STRIP

Temper	Thickness				Minimum Tensile Strength, Lb. per Sq. In.	Minimum Elongation in 2 In., Per Cent
	A.w.g.		In.			
	From	To, Incl.	From	To, Incl.		
0 (Soft)	2	9	0.258	0.114	12,000	30
	9	16	0.114	0.051	12,000	30
	16	20	0.051	0.032	12,000	25
	20	24	0.032	0.020	12,000	20
	24	28	0.020	0.013	12,000	15
4	6	9	0.162	0.114	16,000	7
	9	16	0.114	0.051	16,000	7
	16	20	0.051	0.032	16,000	5
	20	24	0.032	0.020	16,000	4
	24	28	0.020	0.013	16,000	3
6	10	16	0.102	0.051	18,000	5
	16	20	0.051	0.032	18,000	3
	20	24	0.032	0.020	18,000	2
	24	28	0.020	0.013	18,000	2
Hard	10	16	0.102	0.051	22,000	4
	16	20	0.051	0.032	24,000	3
	20	24	0.032	0.020	26,000	2
	24	28	0.020	0.013	30,000	1

PERMISSIBLE TOLERANCES

Thickness				Permissible Tolerance, Plus or Minus, In.
A.w.g.		In.		
From	To, Incl.	From	To, Incl.	
2	4	0.258	0.204	0.0100
4	9	0.204	0.114	0.0060
9	13	0.114	0.072	0.0030
13	21	0.072	0.029	0.0025
21	24	0.029	0.020	0.0020
24	28	0.020	0.013	0.0015

General Information.—The specific gravity of aluminum sheet and strip is about 2.70. Young's modulus of elasticity is about 10,000,000 lb. per sq. in. Aluminum sheet or strip is used for many purposes where the requirements either as to service or as to the forming operations are too specific to be covered in any general specification. It is usually advisable therefore to submit samples or drawings to the manufacturer to assist in the selection of the proper temper for the service or forming operations.

Aluminum sheet or strip is used for automobile bodies, hoods (special flat sheet), fenders, housings, floor coverings, molding, instrument parts, instrument-boards, hub-caps, wire-wheel discs, brake-drum covers, miscellaneous pressings, and for many parts used in aircraft construction.

ZAY JEFFRIES, Chairman

PASSENGER-CAR BODY DIVISION REPORT

The Passenger-Car Body Division has considerable work still in progress. C. D. Holley, of the Acme White Lead & Color Works, is chairman of a Subdivision working on standard specifications for paints, varnishes and enamels. We do

not expect an early report as considerable research work will have to be done before any standards can be formulated. We are also working on the standardization of several types of door hinge.

A Subdivision working under the direction of F. G. Smith, of the American Brass Co., expects to report on steel and brass rolled and drawn shapes at the Summer Meeting of the Standards Committee. This work may be considered as a continuation of the standardization of aluminum molding. George Mercer is chairman of a Subdivision cooperating with the consulting committee of the Central Committee on Lumber Standards in gathering specific data from the body builders as to their hardwood lumber requirements. This work is part of the very comprehensive standardization movement undertaken by the Central Committee on Lumber Standards, which was organized at the request of Secretary Hoover of the Department of Commerce.

Aluminum Sheet

Although the present S.A.E. Non-Ferrous Metal Specifications include aluminum sheet and strip, no attempt has been made to standardize sheet sizes. We realized that the body industry would gain through the elimination of many odd sizes of aluminum sheet, and R. A. LaBarre, of the Towson Body Co., was asked to make a study of the requirements of the industry in this respect and to determine upon a limited number of aluminum sheet sizes that would meet production requirements. Mr. LaBarre's preliminary report specified seven sizes of sheet, all of No. 14 A.w.g. As a result of criticisms received, the report having been submitted for comment to all body-builders, it was considered desirable to include five sizes of sheet of No. 16 gage. No sheets of No. 15 gage were included in the recommendation as the demand for sheets of this gage is small.

The larger producers of automobile bodies will, of course, not always use the sizes recommended, owing to the fact that special sizes are often warranted if purchased in sufficient quantities, but it is believed that the smaller body-producers can adhere to the proposed standards very advantageously. As the sizes proposed are now carried in stock by the mills, the recommendation will not make it necessary for them to carry additional sizes while the standard sizes are coming into further use. The recommendation was printed in the November, 1923, issue of The Journal, on p. 418, but the notes pertaining to the sheet sizes have since been amplified.

Proposed S.A.E. Recommended Practice for Aluminum Sheet Sizes

No. 14 *Gage*	*No.* 16 *Gage*
24 x 72 in.	24 x 72 in.
30 x 96 in.	30 x 96 in.
36 x 120 in.	36 x 120 in.
36 x 144 in.	36 x 144 in.
40 x 144 in.	48 x 144 in.
48 x 144 in.	.....
60 x 120 in.	.....
60 x 144 in.	

Aluminum sheet of No. 14 A. w. g should be obtained in tempers Nos. 4 and 6 for body panels. Sheets of No. 16 A. w. g. should be obtained in temper No. 6 for body panels.

Gray sheets are suitable for stamping except when the original finish of the sheet is depended upon for the final appearance.

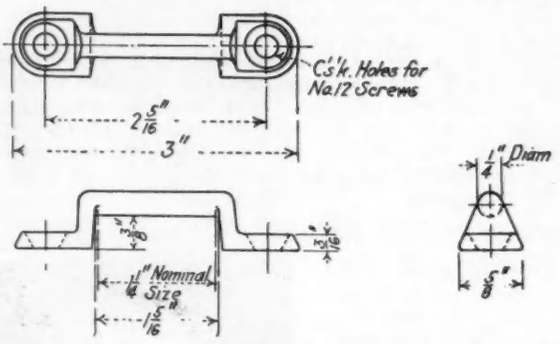
Sheets shall conform to S.A.E. Specification No. 78 for Aluminum Sheet and Strip.

Footman Loops

To simplify conditions for the body builders as well as for the manufacturers of footman loops, we have proposed a standard that will meet with the requirements of the majority of the body builders. The standard calls for a 1¼-in. strap, which is considered amply strong.

The recommendation was published in the January, 1923, issue of The Journal, on p. 126, and if the comments received constitute a criterion, it meets with the general approval of the industry. Some discussion has been had as to the proper nomenclature, it being thought that the article in question should be called "Door-Strap Loop" instead of a "Footman Loop." We consider, however, that the latter name is more widely used and should be retained.

Proposed S.A.E. Recommended Practice for Footman Loops



Upholstery Leather

Excellent work has been accomplished by the Subdivision on Upholstery Leather, of which K. L. Herrmann, of the Studebaker Corporation of America, is chairman. The recommendations are sufficiently concise for use in purchasing and as a manual for inspectors, as well as to establish a satisfactory basis for computing the intrinsic value of the splits used for upholstering. Specifications for such purposes have not been generally available heretofore.

The Subdivision responsible for the specifications was appointed early in 1922 and has held several meetings in different parts of the Country with representatives of the tanners. Mr. Herrmann has also been in close contact at all times with the Tanners' Council, he having spent several days during their convention last winter in explaining the need for proper specifications. The Bureau of Standards, through R. C. Bowker, a member of the Subdivision, has also cooperated in the work, as is evidenced by the notes compiled at the Bureau and published in the October, 1923, issue of The Journal. The complete personnel of the Subdivision is

K. L. Herrmann, *Chairman*	Studebaker Corp. of America
R. C. Bowker	Bureau of Standards
W. N. Davis	Cadillac Motor Car Co.
W. H. Graves	Packard Motor Car Co.
R. K. Mitchell	Maxwell Motor Co., Inc.
F. E. Watts	Hupp Motor Car Corporation

A comprehensive discussion of the specifications will be submitted by Mr. Herrmann at one of the Body Sessions during the Annual Meeting.

Proposed S.A.E. Recommended Practice for Upholstery Leather

PROPOSED SPECIFICATIONS FOR FULL-GRAIN (SNUFFED) UPHOLSTERY LEATHER

These specifications are intended to cover the first split from a hide containing the full grain of the leather, the surface of which is shaved either by hand or machine, removing shavings of no appreciable size or thickness.

A vertical section of full-grain leather shall show that approximately one-third of the thickness is made up of the fine fibers.

A-selection hides shall contain no patches, knife-cuts or knife-scores and 90 per cent shall be free from open grub-holes. Ten per cent may contain up to four open grub-holes. *B*-selection hides may contain four patches not over 1½ in. long and shall not contain more than nine open grub-holes. Table-run hides shall contain not less than 80 per cent *A*-selection and not more than 20 per cent *B*-selection hides.

When agreed upon, single-wire butt-branded hides shall be accepted under these specifications.

Samples consisting of from 10 to 100 hides representative of the cutting value, size and defects of the hides that the seller proposes to furnish under these specifications shall be submitted to the buyer for approval and, if acceptable, will be preserved as standards for reference and test and for comparison with shipments.

The manufacturer's name, the date of shipment and the grade shall be stamped, and the area marked, on all hides.

Hides shall average —— sq. ft. per hide, but no hide shall be less than —— sq. ft. in area. The width across the brisket shall be —— ft.

Hides shall be grained and finished as specified.

The thickness shall be 3/64 in. with tolerances of plus and minus 1/128 in., as measured with a Woburn gage or the equivalent.

Hides shall show no defect or surface blemish affecting the appearance of the material, such as brush marks or stops and bad flows.

Leather must show no evidence of surface cracking when doubled and creased at 32 deg. fahr.

From each 500 hides received a sample measuring 6 x 9 in. shall be cut from a location in the hide representative of the leather that is to be cut into upholstery. The tearing properties of three 3 x 6-in. test-specimens cut from each sample shall be determined by gripping the test-specimens 3 in. apart between jaws that are 1 in. wide on the upper side and 3 in. wide on the under side and pulling in a tensile testing-machine at the rate of 12 in. per min. Test-specimens shall show no evidence of tearing under a load of 100 lb. The elongation at the above load shall not be over 33 per cent.

Failure to comply with any of the above requirements will be cause for the return of the shipment, or any part thereof, for full credit, plus carrying charges both ways.

PROPOSED SPECIFICATIONS FOR MACHINE-BUFFED UPHOLSTERY LEATHER

These specifications are intended to cover the first split from a hide after a thin layer of the grain thickness, called a buffing and approximately 1/64 in. thick, has been removed.

A vertical section of machine-buffed leather shall show some of the thickness is made up of the fine fibers.

A-selection hides shall contain no patches, knife-cuts or knife-scores and 90 per cent shall be free from open grub-holes. Ten per cent may contain up to four open grub-holes. *B*-selection hides may contain four patches not over 1½ in. long and shall not contain more than nine open grub-holes. Table-run hides shall contain not less than 80 per cent *A*-selection and not more than 20 per cent *B*-selection hides.

When agreed upon, single-wire butt-branded hides will be accepted under these specifications.

Samples consisting of from 10 to 100 hides representative of the cutting value, size and defects of the hides that the seller proposes to furnish under these specifications shall be submitted to the buyer for approval and, if acceptable, will be preserved as standards for reference and test and for comparison with shipments.

The manufacturer's name, the date of shipment and the grade shall be stamped, and the area marked, on all hides.

Hides shall average —— sq. ft. per hide, no hide to be less than —— sq. ft. The width across the brisket shall be —— ft.

Hides shall be grained and finished as specified.

The thickness shall be 3/64 in. with tolerances of plus and minus 1/128 in., as measured with a Woburn gage or the equivalent.

Hides shall show no defect or surface blemish affecting the appearance of the material, such as brush marks or stops and bad flows.

Leather shall show no evidence of surface cracking when doubled and creased at 32 deg. fahr.

From each 500 hides received a sample measuring 6 x 9 in. shall be cut from a location in the hide representative of the leather that is to be cut into upholstery. The tearing properties of three 3 x 6-in. test-specimens cut from each sample shall be determined by gripping the test-specimens 3 in. apart between jaws that are 1 in. wide on the upper side and 3 in. wide on the under side and pulling in a tensile testing-machine at the rate of 12 in. per min. Test-specimens shall show no evidence of tearing under a load of 150 lb. The elongation at the above load shall not be over 33 per cent.

Failure to comply with any of the above requirements will be cause for the return of the shipment, or any part thereof, for full credit, plus carrying charges both ways.

PROPOSED SPECIFICATIONS FOR NO. 1 SPLIT UPHOLSTERY LEATHER

These specifications are intended to cover the second split or thickness of a hide obtained after either a full-grain or machine-buffed split has been removed.

A-selection hides shall contain no patches, knife-cuts or knife-scores and 90 per cent shall be free from open grub-holes. Ten per cent may contain up to four open grub-holes. *B*-selection hides may contain four patches not over 1½ in. long and shall not contain more than nine open grub-holes. Table-run hides shall contain not less than 80 per cent *A*-selection hides and not more than 20 per cent *B*-selection hides.

When agreed upon, single-wire butt-branded hides will be accepted under these specifications.

Samples consisting of from 10 to 100 hides representative of the cutting value, size and defects of the hides that the seller proposes to furnish under these specifications shall be submitted to the buyer for approval and, if acceptable, will be preserved as standards for reference and test and for comparison with shipments.

The manufacturer's name, the date of shipment and the grade shall be stamped, and the area marked, on all hides.

Hides shall average —— sq. ft. per hide, no hide to be less than —— sq. ft. The width across the brisket shall be —— ft.

Hides shall be grained and finished as specified.

The thickness shall be 3/64 in., with tolerances of plus and minus 1/128 in., as measured with a Woburn gage or the equivalent.

Hides shall show no defect or surface blemish affecting the appearance of the material, such as brush marks or stops and bad flows.

From each 500 hides received a sample measuring 6 x 9 in. shall be cut from a location in the hide representative of the leather that is to be cut into upholstery. The tearing properties on three 3 x 6-in. test-specimens cut from each sample shall be determined by gripping the test-specimens 3 in. apart between jaws that are 1 in. wide on the upper side and 3 in. wide on the under side and pulling in a tensile testing-machine at the rate of 12 in. per min. Test-specimens shall show no evidence of tearing under a load of 200 lb. The elongation at the above load shall not be over 33 per cent.

Failure to comply with any of the above requirements will be cause for the return of the shipment, or any part thereof, for full credit, plus carrying charges both ways.

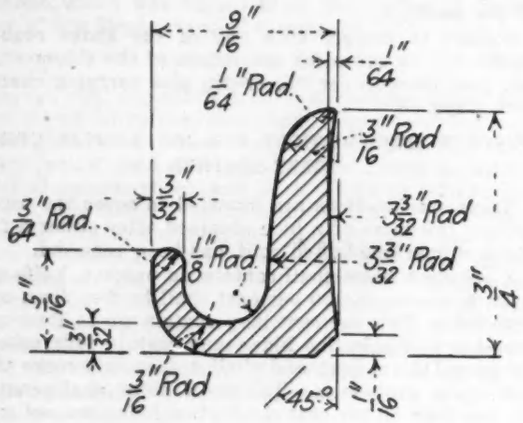
Aluminum Molding

The report of the Subdivision of Aluminum Molding, of which W. D. Foote, of the Aluminum Co. of America, is chairman, received final Division approval at our last meeting. The original report was printed in the May, 1923, issue of THE JOURNAL, but in view of comments received from Society members, it was considered advisable to limit the report to drip and belt molding only, the demand for ell and tee molding being limited. The revised report was printed in the October, 1923, issue of THE JOURNAL, on p. 343.

The adoption of the proposed recommended practice in actual production would eliminate the great variety of types and sizes that are used in the industry today and make unnecessary the large investment in tools and stock that increases the cost of production. The types of belt molding proposed are recognized as standard at the present time and it is believed that the sizes proposed will meet all future requirements, the standards being intended for adoption as soon as changes in production and design are economically feasible.

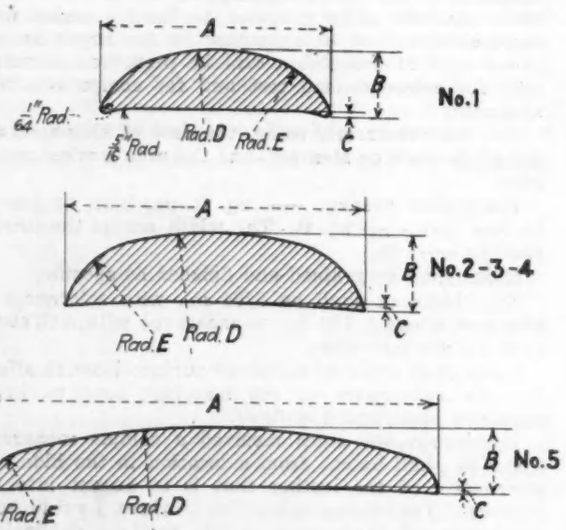
A. J. NEERKEN, Chairman.

Aluminum Drip Molding Proposed as S.A.E. Recommended Practice



Estimated weight per linear foot: 0.180 lb.

Proposed S. A. E. Recommended Practice for Aluminum Belt Molding



No.	A	B	C	D	E	Estimated Weight Per Foot, Lb.
1	0.770	0.223	0.016	0.625	0.313	0.143
2	7/8	1/4	0.025	0.875	0.281	0.186
3	1	1/4	0.025	1.094	0.281	0.228
4	1 1/4	1/4	0.025	1 1/4	0.344	0.286
5	1 1/2	7/32	0.016	2 3/8	3/4	0.331

PARTS AND FITTINGS DIVISION REPORT

W. C. KEYS

Since the Standards Committee Meeting at Spring Lake, the Parts and Fittings Division has been considering five subjects: Fuel and Lubrication Pipe-Fittings, Flexible-Discs, Wire Cloth, License-Plate Mountings and Brake-Lining. Definite recommendations have now been approved for pipe fittings and flexible discs.

A. W. Weaver has been working on the standardization of wire cloth, a tentative report having been published in the December, 1923, issue of THE JOURNAL on p. 502. Shipment of wire cloth direct from the manufacturers' stocks, quicker deliveries, smaller inventories and lower prices are cited as probable results of the adoption of the wire-cloth standard in future practice. We expect that Mr. Weaver's report will be ready for action at the Summer Meeting of the Standards Committee.

The work on license-plate mountings is progressing slowly owing to the fact that it is necessary to obtain the approval of the officials who are responsible for such matters in the different States. In many States it probably will be necessary to revise existing laws to obtain uniformity. We feel that much will be accomplished, however, as the members of the Eastern Conference of Motor Vehicle Administrators appreciate the importance of uniform legislation for license-plate mountings and are cooperating with us.

The Subdivision on Brake-Lining, of which Clarence Carson, of Dodge Bros., is chairman, is continuing its work on brake-lining specifications. It will be remembered that S. von Ammon, of the Bureau of Standards, presented a paper at the 1922 Annual Meeting covering the work that the Bureau of Standards had been doing on this subject and describing testing machines that had been built. Similar machines have been built by the Subdivision members and several meetings have been held to discuss the results obtained. The work of Mr. Carson's Subdivision is most important and we hope to have a report covering its status at an early date.

Fuel and Lubrication Pipe-Fittings

The Parts and Fittings Division has realized for some time that the present S. A. E. Recommended Practice for fuel and lubrication pipe-fittings of the flared tube and the soldered types should be supplemented with compression-type fittings in view of the extent to which the last-named type is being used. Early in 1922 we appointed a Subdivision consisting of W. H. Hollister, of the Imperial Brass Co., who acted as chairman, and W. J. Outcalt, of the General Motors Corporation. The first report of the Subdivision was published in the June, 1923, issue of THE JOURNAL on p. 581. Although it was our original intention to submit the Subdivision recommendation for action at the Standards Committee Meeting at Spring Lake, it was withdrawn at the last moment owing to comments received.

The type of compression fitting proposed for recommended practice is made by several manufacturers with slight variations in the detailed dimensions. It was necessary to analyze

the various dimensions used and decide upon such dimensions as would make it possible for the several manufacturers to adopt the standard without costly production changes.

A special meeting was held in Detroit on Oct. 18, at which the Subdivision members met with representatives of the various compression-type fitting manufacturers and reviewed the original recommendation. Representatives of the following companies attended this meeting: Commonwealth Brass Corporation, General Motors Corporation, Imperial Brass Mfg. Co., McRae & Roberts Co., Mueller Metals Co. and Ohio Metal Products Co.

The dimensions agreed upon at this meeting were submitted to the members of the Division at a meeting held the same day and met with general approval. The revisions made in the original recommendation, taken individually, are of minor importance, but collectively they represent a careful refinement and correlation of corresponding dimensions for similar parts.

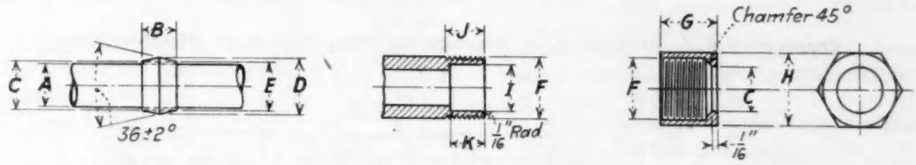
The recommendation was printed in the December, 1923, issue of THE JOURNAL, on p. 508, in order that any members desiring to submit comments or criticisms might do so in time for the Division to act on them before the Standards Committee Meeting.

[As this report goes to press there remains some question regarding the right of the several manufacturers to make and market the proposed compression type of pipe fittings under existing patent conditions, but it is expected that a definite decision in this connection will have been reached among the manufacturers by the time this report is presented to the Standards Committee on Jan. 22.]

FLEXIBLE-DISCS

During the past year a Subdivision consisting of C. W. Spicer, of the Spicer Mfg. Corporation, and E. W. Templin, of the Goodyear Tire & Rubber Co., has been developing a standard for propeller-shaft flexible-discs. A tentative Subdivision report was submitted in April of this year and published in the July, 1923, issue of THE JOURNAL. Copies of

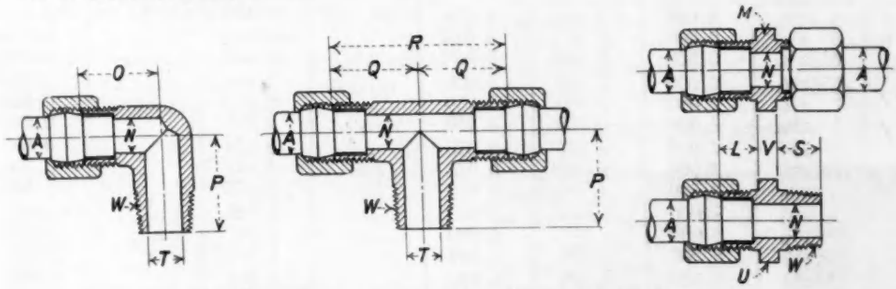
Compression-Type Fuel and Lubrication Pipe-Fittings Proposed by Parts and Fittings Division



PROPOSED DIMENSIONS FOR COLLARS, NUTS AND STRAIGHT THREADED-ENDS

Tubing Diameter *A*	*B*	Collar Bore *C* Maximum	Collar Bore *C* Minimum	*D*	Small Diameter of Taper *E*	*F*[4]	*G*	*H*	*I* ±0.002	*J* Minimum	*K*
1/8	3/16	0.130	0.126	3/16	0.140	5/16–24	11/32	3/8	0.136	1/4	3/16
5/32	7/32	0.195	0.191	17/64	0.205	3/8–24	3/8	7/16	0.196	9/32	7/32
1/4	1/4	0.259	0.255	11/32	0.269	7/16–24	13/32	1/2	0.261	5/16	1/4
5/16	9/32	0.325	0.321	13/32	0.335	1/2–24	7/16	9/16	0.328	11/32	9/32
3/8	5/16	0.388	0.384	15/32	0.398	9/16–24	15/32	5/8	0.391	3/8	5/16
1/2	3/8	0.517	0.513	19/32	0.527	11/16–20	5/8	13/16	0.531	7/16	3/8

All dimensions in inches.
[4] U. S. Standard Thread.



PROPOSED DIMENSIONS FOR ELBOWS, TEES AND UNIONS

Tubing Diameter *A*	*L*	Diameter of Hexagon *M*	*N*	*O*	*P*	*Q*	*R*	*S*	*T*	Diameter of Hexagon *U*	*V*	*W*[5]
1/8	1/4	5/16	3/32	5/8	11/16	11/16	1 3/8	3/8	3/16	7/16	5/32	1/8
3/16	9/32	3/8	1/8	5/8	11/16	11/16	1 3/8	3/8	3/16	7/16	3/16	1/8
1/4	5/16	7/16	3/16	5/8	3/4	11/16	1 3/8	3/8	3/16	7/16	3/16	1/8
5/16	11/32	1/2	1/4	5/8	3/4	11/16	1 3/8	3/8	1/4	1/2	3/16	1/8
3/8	3/8	9/16	5/16	3/4	7/8	13/16	1 5/8	7/16	5/16	9/16	7/32	1/4
1/2	7/16	11/16	13/32	15/16	1 1/8	1	2	1/2	13/32	11/16	7/32	3/8

All dimensions in inches.
[5] American Standard Pipe Thread.

the report were also submitted to the flexible-disc manufacturers and users for comment. The report was based on information obtained from both users and manufacturers on the assumption that an unnecessarily large variety of propeller-shaft flexible-discs was in general use, thus working an unnecessary hardship on the disc manufacturer as well as the service man. The information obtained bore out this assumption and the report, with the exception of the torque ratings proposed, met with general approval.

To obtain final definite agreement, a meeting of the Subdivision was held at Detroit in October with representatives of the flexible-disc manufacturers. The original report was revised as a result of this meeting, and approved by the Division members at a meeting held on the following day. At the latter meeting it was stated that if the recommendation is adopted in future practice a reduction from 155 to 21 in the number of sizes of discs used will be effected. The detailed changes made in the original Subdivision report were set forth on p. 504 of the December, 1923, issue of THE JOURNAL.

W. C. KEYS, Chairman.

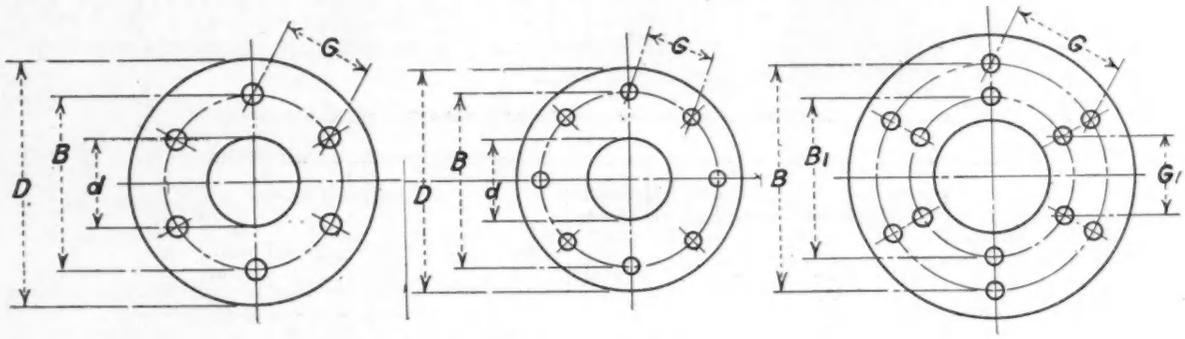
STORAGE-BATTERY DIVISION REPORT

At a meeting of the Storage-Battery Division held in May recommendations were received from the Automotive Simplified Practice Committee as a result of a survey of the storage-battery situation in the automotive industry. This survey indicated that over 85 per cent of the batteries used on passenger cars conform to the present S.A.E. Standard for storage-battery dimensions.

The Automotive Simplified Practice Committee recommended that the Storage-Battery Division establish definite storage-battery compartment lengths that would be satisfactory for the standard storage-battery sizes, the lengths to be selected so that batteries of the next larger capacity than the original equipment might be used if desired; that the Storage-Battery Division review the present S.A.E. Standard to determine whether any revision thereof were desirable and that definite dimensions for the hold-down devices be included.

Accordingly, we have reviewed thoroughly the present S.A.E. Standard for Lead-Acid Storage Batteries, p. B23

Proposed S.A.E. Recommended Practice for Propeller-Shaft Flexible-Discs



Type	Nominal Size	Outside Diameter *D* ±0.030	Inside Diameter *d* ±0.030	Bolt-Circle Diameter ±0.010		*G* ±0.010	*G1* ±0.010	Bolt-Hole Diameter +0.010 −0.000	Thickness +0.020 −0.010
				B	*B1*				
Six-Hole	6 x5/16	6.000	2.250	4.625	.....	2.313	.....	0.438	0.313
	6 x3/8[a]	6.000	2.250	4.625	.....	2.313	.....	0.500	0.375
	6½x¼	6.500	2.500	5.000	.....	2.500	.....	0.438	0.250
	6½x5/16	6.500	2.500	5.000	.....	2.500	.....	0.500	0.313
	7 x¼	7.000	2.750	5.250	.....	2.625	.....	0.500	0.250
	7 x5/16	7.000	2.750	5.250	.....	2.625	.....	0.500	0.313
	7 x3/8	7.000	2.750	5.250	.....	2.625	.....	0.500	0.375
	7½x5/16	7.500	2.750	5.625	.....	2.813	.....	0.500	0.313
	7½x3/8	7.500	2.750	5.625	.....	2.813	.....	0.500	0.375
	8 x5/16	8.000	3.000	6.000	.....	3.000	.....	0.625	0.313
	8 x3/8	8.000	3.000	6.000	.....	3.000	.....	0.625	0.375
	8½x5/16	8.500	3.000	6.250	.....	3.125	.....	0.625	0.313
	8½x3/8	8.500	3.000	6.250	.....	3.125	.....	0.625	0.375
	9 x3/8	9.000	3.250	6.500	.....	3.250	.....	0.625	0.375
Eight-Hole	6½x5/16	6.500	2.750	4.750	.....	1.818	.....	0.375	0.313
	7½x5/16	7.500	2.750	5.625	.....	2.153	.....	0.438	0.313
	7½x13/32	7.500	2.750	5.625	.....	2.153	.....	0.438	0.406
	8¼x5/16	8.250	3.000	6.500	.....	2.487	.....	0.500	0.313
Double-Row	9½x5/16	9.500	3.250	8.000	5.750	4.000	2.875	0.500	0.313
	9½x3/8	9.500	3.250	8.000	5.750	4.000	2.875	0.500	0.375
	10½x3/8	10.500	4.250	8.500	6.000	4.250	3.000	0.500	0.375

All dimensions in inches.
[a] This size of disc is used principally for coupling between engines and transmissions.

of the S.A.E. HANDBOOK, and have agreed on certain revisions and extensions that we believe will make the standard of more value to the industry. As it is not easy to tell from the revised standard proposed by the Division what changes have been made, the more important changes are noted herewith.

(1) Battery Nos. 4, 6 and 9 (old numbers) have been eliminated as being obsolete
(2) The maximum overall length of batteries has been reduced slightly
(3) The 7½-in. maximum overall width has been reduced ⅛-in.
(4) The maximum overall height for batteries Nos. 1, 2, 3 and 5 has been increased ⅛ in.
(5) A new battery, No. 7, has been added
(6) Battery compartment lengths of 12, 13½, 14¾ and 18¾ in. have been specified
(7) The inside compartment-height has been increased ⅜ in.
(8) Dimensions for hold-down devices have been specified
(9) Dimensions for straight terminal-posts have been eliminated

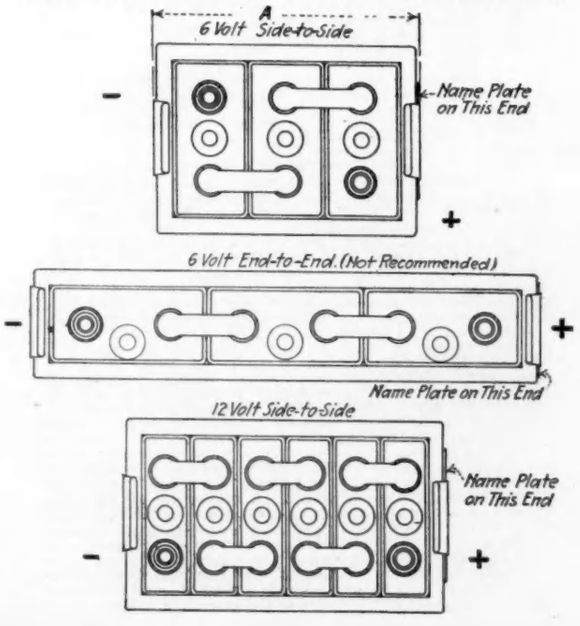
Owing to the increase in use of starting and lighting equipment on motor trucks, we have thought it best to limit the present standard to passenger cars only. We plan to formulate an additional standard for motor trucks and motorbuses because their requirements are special, necessitating larger battery capacities and the ability to withstand more violent vibration as a result of heavy-duty service.

Revised S.A.E. Standard Proposed for Lead-Acid Storage-Batteries

Application.—These specifications are intended to apply only to lead-acid storage-batteries used in passenger-cars for starting and lighting.

Ratings.—Batteries for combined starting and lighting service shall have two ratings. The first rating shall indicate the lighting ability and shall be the capacity in ampere-hours of the battery when it is discharged continuously at the 5-hr. rate to a final voltage of not less than 1.7 per cell, the temperature of the battery at the beginning of such discharge being 80 deg. fahr. The second rating shall indicate the starting ability and shall be the capacity in ampere-hours of the battery when it is discharged continuously at the 20-min. rate to a final voltage of not less than 1.5 per cell, the temperature of the battery at the beginning of such discharge being 80 deg. fahr.

Location of Battery Parts.—The location and polarity of the terminal posts and the position of the handles and the name-plates shall be as shown in the accompanying illustration.



DIMENSIONS OF STORAGE-BATTERIES

No.	No. of Cells	Minimum Capacity, Amp-Hr.		Maximum Overall Dimensions, In.[a]		
		5-Hr. Rate	20-Min. Rate	Length *A*	Width	Height
1	3(*b*)	60	31	9⅜	7⅜	10
2	3(*b*)	72	37	10¾	7⅜	10
3	3(*b*)	84	43	12¼	7⅜	10
4	3(*b*)	96	50	13½	7⅜	10
5	3(*c*)	95	43	20⅝	5⅝	9½
6	6(*d*)	36	19	12¾	7⅜	10⅛
7	6(*d*)	60	31	17⅜	7⅜	10

[a] The overall end-to-end length of passenger-car batteries for starting and lighting service includes handles, but not hold-down devices. The handles and the hold-down devices shall be attached only to the ends of the case. Terminals and connections shall not extend above the handles; the latter shall be the highest point.
(*b*) Arrangement of cells to be as shown in the top drawing.
(*c*) End-to-end assembly of jars shown in middle drawing is not recommended because of the inherent weakness of this type of construction.
(*d*) Arrangement of cells to be as shown in bottom drawing.

Terminal Posts.—When taper posts are used for terminals of lead-acid storage-batteries, the dimensions in inches shall be:

Small Diameter of the Negative Post	⅝
Small Diameter of the Positive post	11/16
Taper per Foot	1 1/3
Minimum Length of Taper	11/16

Compartments.—Compartments for starting and lighting batteries shall be of metal of not less than No. 18 U. S. S. gage (0.050 in.), and supported entirely by the chassis.

The inside width of the compartments shall be 8 in. and the height from the bottom shall be 10½ in. The inside lengths shall be 12, 13½, 14¾ and 18¾ in.

The battery shall rest on two wooden strips, each 2 in. wide and ¼ in. thick, running lengthwise of the compartment and positively spaced with the edges flush with the sides of the battery.

Hold-Down Devices.—Hold-down devices shall be attached at the top of each end of the battery case, not at the top of the handles. The diameter of the hold-down rods shall be ¼ in. The diameter of the rod holes in the hold-down devices shall be ⅜ in., and their centers shall be 3/16 in. from the ends of the battery case. Hold-down devices shall not extend more than 17/32 in. beyond each end of the battery case.

IRVINE M. NOBLE, Chairman.

SCREW-THREADS DIVISION REPORT

E. H. EHRMAN

The development of the specifications contained in the Report of the Sectional Committee on Screw-Threads entitled, Standard Screw-Threads for Bolts, Machine-Screws, Nuts and Commercially Tapped Holes, in which the Society as a joint sponsor has been asked to approve, has a history so far as the Society is concerned dating back to 1910.

At about this time a tentative specification for S.A.E. bolt and nut threads, based on the tolerances in the American Society of Mechanical Engineers Machine-Screw Specifications, was formulated by the Miscellaneous Division of the Standards Committee, and samples, threaded to the

maximum and to the minimum limits, were submitted to members of the Standards Committee for inspection. Following this, the specification was put into practice by an interested manufacturer for the purpose of determining, through actual experience, whether or not the specification would prove acceptable to makers and users alike.

In 1918, there was created by act of Congress, a National Screw-Thread Commission for service on which this Society and the American Society of Mechanical Engineers each nominated two members. Thereafter the work of the Society in this line was coordinated with that of the Commission. The putting into practice of the tentative specification by the Miscellaneous Division proved of value, as the tried specification, together with another having a slightly greater tolerance-range, furnished dependable foundations for two series, Classes 11A and 11B, in the Progress Report of the Commission.

In May, 1919, the Commission issued a preliminary report which was reviewed very carefully by a special committee appointed by the Society for the purpose. The committee made valuable recommendations that were incorporated in the final specifications of the Progress Report, approved by the Commission in June, 1920, and published in January, 1921.

Shortly thereafter, a Sectional Committee, sponsored jointly by the American Society of Mechanical Engineers and the Society, was organized under the rules of procedure of the American Engineering Standards Committee, to review the Progress Report of the National Screw Thread Commission and to make available promptly those parts of the specifications that had already received the approval of the working committee of the Sectional Committee. The Screw-Threads Division, about a year ago, recommended such specifications for adoption by the Society, but, because of pending changes that might have affected the specifications, the Council of the Society wisely withheld their publication.

The Sectional Committee completed its task shortly before the time of the holding of the Summer Meeting of the Society at Spring Lake last year, but the Society took no action on the report at that time, as formal approval would of necessity have been hurried and would have lacked the deliberate action demanded by a matter of such importance. At a meeting in September, 1923, the Screw-Threads Division gave careful consideration to the report, particularly with respect to the application of the specifications to S.A.E. Standards. The action taken is, perhaps, best stated by quoting from the minutes of that meeting.

> It was explained that the work of the Screw-Threads Division on this subject is in three parts:
>
> (1) Approval of the Sectional Committee Report by the Society as a sponsor
>
> (2) To select such portions of the Report as should be recommended for adoption as S.A.E. Standards
>
> (3) A general review of all S.A.E. Standards in which screw-threads are specified, for the purpose of recommending their revision in accordance with the Report
>
> The complete Sectional Committee Report was discussed as to its scope, limited application, to fastening units only, and the inflexibility of some portions, particularly with respect to the allowance for the neutral zone. It was brought out that practice indicates that the neutral zone finds application above as well as below basic size, the disposition of the allowance depending upon individual conditions to be met. It was agreed that the specifications should be broad enough to cover all requirements in the automotive industry. It was also explained that the development of the Report with its present limited application is largely the result of an endeavor to avoid delays that would be incidental to the development of, or changes in, the present specifications to give them the desired broadness. It was stated that the work along this line is already under way by a Committee of the National Screw-Threads Commission.
>
> The Division felt that the loose-fit class as given in the Report will find occasional application in the S.A.E. Standards and other automotive work, but that the disposition of the neutral zone will necessarily have to vary.
>
> On motion by Mr. Buckingham, seconded by Mr. Case, it was voted unanimously that
>
> The Division recommends approval by the Society, as a sponsor, of the Sectional Committee Report on Screw-Threads, with the comment that at present the Division sees no application in automotive work for the "loose-fit class" for screws with the neutral zone definitely placed. It is understood by the Division that this report refers to screw-threads for fastening-unit purposes only. The Division is working concurrently with the National Screw-Thread Commission toward developing a specification for standard tolerances for units other than those used primarily for fastening means; this will be submitted at a later date.

By this action the Division definitely recommend that the Society as a sponsor approve the Sectional Committee Report for adoption as Tentative American Standard. Copies of the report will be available in pamphlet form upon request.

The Division also recommends that the accompanying text and tables of the Report be adopted as S.A.E. Standard and printed in the S.A.E. HANDBOOK.

Screw-Threads

TABLE 1—S.A.E. STANDARD SCREW-THREAD SERIES

Diameter, In.	Basic Major Diameter, In.	Threads Per Inch		
		Coarse[7]	Fine[8]	Extra Fine[9]
0	0.0600	.....	80	.....
1	0.0730	64	72	.....
2	0.0860	56	64	.....
3	0.0990	48	56	.....
4	0.1120	40	48	.....
5	0.1250	40	44	.....
6	0.1380	32	40	.....
8	0.1640	32	36	.....
10	0.1900	24	32	.....
12	0.2160	24	28	.....
1/4	0.2500	20	28	36
5/16	0.3125	18	24	32
3/8	0.3750	16	24	32
7/16	0.4375	14	20	28
1/2	0.5000	13	20	28
9/16	0.5625	12	18	24
5/8	0.6250	11	18	24
3/4	0.7500	10	16	20
7/8	0.8750	9	14	20
1	1.0000	8	14	20
1 1/8	1.1250	7	12	18
1 1/4	1.2500	7	12	18
1 1/2	1.5000	6	12	18
1 3/4	1.7500	5	12(e)	16
2	2.0000	4 1/2	12(e)	16
2 1/4	2.2500	4 1/2	12(e)	16
2 1/2	2.5000	4	12(e)	16
2 3/4	2.7500	4	12(e)	16
3	3.0000	4	10(e)	16
Over 3 to 6	.....	.....	10(e)	16
Over 6	.....	.....	8(e)	16

[7]The S.A.E. Coarse Screw-Thread Series, supplemented below the 1/4-in. size by the standard established by the Amerian Society of Mechanical Engineers in 1907, is the "United States Standard" Screw-Thread Series, sometimes termed the "American" or "National" Coarse Screw-Thread Series.

[8]The S.A.E. Fine Screw-Thread Series, which was adopted by the Society in August, 1922, was formulated for fractional-inch sizes up to and including 1 in. by the Mechanical Branch of the Association of Licensed Automobile Manufacturers (A. L. A. M.), now the National Automobile Chamber of Commerce (N. A. C. C.), for automotive applications where U. S. Standard screw-threads were too coarse. In 1911 the A. L. A. M. made the Society (S.A.E.) the custodian of the A. L. A. M. Standards, this series then becoming the S.A.E. Regular Screw-Thread Series. This was subsequently extended by the S.A.E. to include fractional-inch sizes above 2 in. The sizes below 1/4-in. are in accordance with the series established by the American Society of Mechanical Engineers (A. S. M. E.). The present S.A.E. Fine Series is sometimes termed either the "American" or "National" Fine Series.

[9]The S.A.E. Extra Fine Screw-Thread Series was adopted by the Society in 1915 as the S.A.E. Fine Series for aeronautic and other applications where screw-threads finer than S.A.E. Fine Screw-Thread Series are necessary. Tolerances for the extra-fine screw-thread series are not covered by the following tables, but will be covered in a subsequent report of the Screw-Threads Division dealing primarily with fine-pitch large-diameter screw-threads with short engagements.

(e) These pitches are suitable for work requiring short engagement where it is not practical to specify tolerances for all conditions. They are not, therefore, included in the succeeding tables.

THREAD FORM

The form of thread profile specified, known previously as the United States Standard or Sellers' Profile, shall hereafter be known as the American (National) Form of Thread.

The basic angle of thread between the sides of the thread measured in an axial plane shall be 60 deg. The line bisecting this 60-deg. angle shall be perpendicular to the axis of the screw-thread.

The basic width of flat at the root and crest of the thread form is found as follows:

$$F = \tfrac{1}{8} \times p \text{ or } 0.125 \times p$$

The basic depth of the thread form is found as follows:

$$h = 0.649519 \times p$$
$$= 0.649519/n$$

where

n = number of threads per inch
p = pitch in inches

A clearance shall be provided at the minor diameter of the nut by removing the thread form at the crest by an amount between one-sixth and one-fourth of the basic thread-depth.

A clearance at the major diameter of the nut shall be provided by decreasing the depth of the truncation triangle any desired amount down to one-third of its theoretical value.

TABLE 2—BASIC DIAMETERS AND THREAD DATA FOR THE COARSE-THREAD SERIES

Sizes	Threads per Inch (r)	Basic Major Diameter (D)	Basic Pitch Diameter (E)	Basic Minor Diameter (K)	Pitch[10] (p)	Basic Depth of Thread (h)
1	64	0.0730	0.0629	0.0527	0.0156250	0.0101
2	56	0.0860	0.0744	0.0628	0.0178571	0.0116
3	48	0.0990	0.0855	0.0719	0.0208333	0.0135
4	40	0.1120	0.0958	0.0795	0.0250000	0.0162
5	40	0.1250	0.1088	0.0925	0.0250000	0.0162
6	32	0.1380	0.1177	0.0974	0.0312500	0.0203
8	32	0.1640	0.1437	0.1234	0.0312500	0.0203
10	24	0.1900	0.1629	0.1359	0.0416667	0.0271
12	24	0.2160	0.1889	0.1619	0.0416667	0.0271
1/4	20	0.2500	0.2175	0.1850	0.0500000	0.0325
5/16	18	0.3125	0.2764	0.2403	0.0555556	0.0361
3/8	16	0.3750	0.3344	0.2938	0.0625000	0.0406
7/16	14	0.4375	0.3911	0.3447	0.0714286	0.0464
1/2	13	0.5000	0.4500	0.4001	0.0769231	0.0500
9/16	12	0.5625	0.5084	0.4542	0.0833333	0.0541
5/8	11	0.6250	0.5660	0.5069	0.0909091	0.0590
3/4	10	0.7500	0.6850	0.6201	0.1000000	0.0650
7/8	9	0.8750	0.8028	0.7307	0.1111111	0.0722
1	8	1.0000	0.9188	0.8376	0.1250000	0.0812
1 1/8	7	1.1250	1.0322	0.9394	0.1428571	0.0928
1 1/4	7	1.2500	1.1572	1.0644	0.1428571	0.0928
1 1/2	6	1.5000	1.3917	1.2835	0.1666667	0.1083
1 3/4	5	1.7500	1.6201	1.4902	0.2000000	0.1299
2	4 1/2	2.0000	1.8557	1.7113	0.2222222	0.1443
2 1/4	4 1/2	2.2500	2.1057	1.9613	0.2222222	0.1443
2 1/2	4	2.5000	2.3376	2.1752	0.2500000	0.1624
2 3/4	4	2.7500	2.5876	2.4252	0.2500000	0.1624
3	4	3.0000	2.8376	2.6752	0.2500000	0.1624

All dimensions in inches.
[10]This column is given to seven decimal places for computation purposes only.

TABLE 3—LOOSE FIT (CLASS 1) FOR NUTS IN THE COARSE-THREAD SERIES[11]

Size	Threads per Inch	Minimum Major Diameter[13]	Pitch Diameter			Minor Diameter		
			Minimum[12]	Tolerance[14]	Maximum	Minimum	Tolerance	Maximum
1	64	0.0730	0.0629	0.0026	0.0655	0.0561	0.0017	0.0578
2	56	0.0860	0.0744	0.0028	0.0772	0.0667	0.0019	0.0686
3	48	0.0990	0.0855	0.0031	0.0886	0.0764	0.0023	0.0787
4	40	0.1120	0.0958	0.0034	0.0992	0.0849	0.0027	0.0876
5	40	0.1250	0.1088	0.0034	0.1122	0.0979	0.0027	0.1006
6	32	0.1380	0.1177	0.0038	0.1215	0.1042	0.0034	0.1076
8	32	0.1640	0.1437	0.0038	0.1475	0.1302	0.0034	0.1336
10	24	0.1900	0.1629	0.0046	0.1675	0.1449	0.0045	0.1494
12	24	0.2160	0.1889	0.0046	0.1935	0.1709	0.0045	0.1754

All dimensions in inches.
[11]This fit is recommended for nuts only in the numbered series.
[12]Basic diameter. Dimensions given are allowable only with tap having theoretically sharp corners. Threaded hole must not reject correct basic "Go" gage by interference with rounded roots due to worn tap. Minimum flat at root equals $1/24 \times p$.
[13]Basic diameter.
[14]The tolerances specified for the pitch diameter are cumulative and include all errors of lead and angle.

TABLE 4—FREE FIT (CLASS 2) FOR SCREWS IN THE COARSE-THREAD SERIES

Size	Threads per Inch	Major Diameter			Pitch Diameter			Maximum Minor Diameter[17]
		Maximum[15]	Tolerance	Minimum	Maximum[15]	Tolerance[16]	Minimum	
1	64	0.0730	0.0038	0.0692	0.0629	0.0019	0.0610	0.0538
2	56	0.0860	0.0040	0.0820	0.0744	0.0020	0.0724	0.0641
3	48	0.0990	0.0044	0.0946	0.0855	0.0022	0.0833	0.0754
4	40	0.1120	0.0048	0.1072	0.0958	0.0024	0.0934	0.0813
5	40	0.1250	0.0048	0.1202	0.1088	0.0024	0.1064	0.0943
6	32	0.1380	0.0054	0.1326	0.1177	0.0027	0.1150	0.0997
8	32	0.1640	0.0054	0.1586	0.1437	0.0027	0.1410	0.1257
10	24	0.1900	0.0066	0.1834	0.1629	0.0033	0.1596	0.1389
12	24	0.2160	0.0066	0.2094	0.1889	0.0033	0.1856	0.1649
1/4	20	0.2500	0.0072	0.2428	0.2175	0.0036	0.2139	0.1887
5/16	18	0.3125	0.0082	0.3043	0.2764	0.0041	0.2723	0.2443
3/8	16	0.3750	0.0090	0.3660	0.3344	0.0045	0.3299	0.2983
7/16	14	0.4375	0.0098	0.4277	0.3911	0.0049	0.3862	0.3499
1/2	13	0.5000	0.0104	0.4896	0.4500	0.0052	0.4448	0.4056
9/16	12	0.5625	0.0112	0.5513	0.5084	0.0056	0.5028	0.4603
5/8	11	0.6250	0.0118	0.6132	0.5660	0.0059	0.5601	0.5135
3/4	10	0.7500	0.0128	0.7372	0.6850	0.0064	0.6786	0.6273
7/8	9	0.8750	0.0140	0.8610	0.8028	0.0070	0.7958	0.7387
1	8	1.0000	0.0152	0.9848	0.9188	0.0076	0.9112	0.8466
1 1/8	7	1.1250	0.0170	1.1080	1.0322	0.0085	1.0287	0.9497
1 1/4	7	1.2500	0.0170	1.2330	1.1572	0.0085	1.1487	1.0747
1 1/2	6	1.5000	0.0202	1.4798	1.3917	0.0101	1.3816	1.2955
1 3/4	5	1.7500	0.0232	1.7268	1.6201	0.0116	1.6085	1.5046
2	4 1/2	2.0000	0.0254	1.9746	1.8557	0.0127	1.8430	1.7274
2 1/4	4 1/2	2.2500	0.0254	2.2246	2.1057	0.0127	2.0930	1.9774
2 1/2	4	2.5000	0.0280	2.4720	2.3376	0.0140	2.3236	2.1933
2 3/4	4	2.7500	0.0280	2.7220	2.5876	0.0140	2.5736	2.4433
3	4	3.0000	0.0280	2.9720	2.8376	0.0140	2.8236	2.6933

All dimensions in inches.
[15]Basic diameter.
[16]The tolerances specified for pitch diameter are cumulative and include all errors of lead and angle.
[17]Dimensions given are figured to intersection of the worn tool arc with a centerline through crest and root. Minimum flat at at root equals $\frac{1}{8} \times p$.

TABLE 5—BASIC DIAMETER AND THREAD DATA FOR THE FINE-THREAD SERIES

Size	Threads per Inch r	Major Diameter D	Pitch Diameter E	Minor Diameter K	Pitch[18] p	Basic Depth of Thread h
0	80	0.0600	0.0519	0.0438	0.0125000	0.00812
1	72	0.0730	0.0640	0.0550	0.0138889	0.00902
2	64	0.0860	0.0759	0.0657	0.0156250	0.01014
3	56	0.0990	0.0874	0.0758	0.0178571	0.01160
4	48	0.1120	0.0985	0.0849	0.0208333	0.01353
5	44	0.1250	0.1102	0.0955	0.0227273	0.01476
6	40	0.1380	0.1218	0.1055	0.0250000	0.01624
8	36	0.1640	0.1460	0.1279	0.0277778	0.01804
10	32	0.1900	0.1697	0.1494	0.0312500	0.02030
12	28	0.2160	0.1928	0.1696	0.0357143	0.02319
1/4	28	0.2500	0.2268	0.2036	0.0357143	0.02319
5/16	24	0.3125	0.2854	0.2584	0.0416667	0.02706
3/8	24	0.3750	0.3479	0.3209	0.0416667	0.02706
7/16	20	0.4375	0.4050	0.3725	0.0500000	0.03248
1/2	20	0.5000	0.4675	0.4350	0.0500000	0.03248
9/16	18	0.9625	0.5264	0.4903	0.0555556	0.03608
5/8	18	0.6250	0.5889	0.5528	0.0555556	0.03608
3/4	16	0.7500	0.7094	0.6688	0.0625000	0.04060
7/8	14	0.8750	0.8286	0.7822	0.0714286	0.04640
1	14	1.0000	0.9536	0.9072	0.0714286	0.04640
1 1/8	12	1.1250	1.0709	1.0167	0.0833333	0.05413
1 1/4	12	1.2500	1.1959	1.1417	0.0833333	0.05413
1 1/2	12	1.5000	1.4459	1.3917	0.0833333	0.05413

All dimensions in inches.
[18]This column is given to seven decimal places for computation purposes only.

TABLE 6—LOOSE FIT (CLASS 1) FOR NUTS IN THE FINE-THREAD SERIES[19]

Size	Threads per Inch	Minimum Major Diameter[20]	Pitch Diameter			Minor Diameter		
			Minimum[21]	Tolerance[22]	Maximum	Minimum	Tolerance	Maximum
0	80	0.060	0.0519	0.0024	0.0543	0.0465	0.0013	0.0478
1	72	0.073	0.0640	0.0025	0.0665	0.0580	0.0015	0.0595
2	64	0.086	0.0759	0.0026	0.0785	0.0691	0.0017	0.0708
3	56	0.099	0.0874	0.0028	0.0902	0.0797	0.0019	0.0816
4	48	0.112	0.0985	0.0031	0.1016	0.0894	0.0023	0.0917
5	44	0.125	0.1102	0.0032	0.1134	0.1004	0.0025	0.1029
6	40	0.130	0.1218	0.0034	0.1252	0.1109	0.0027	0.1136
8	36	0.164	0.1460	0.0036	0.1496	0.1339	0.0030	0.1369
10	32	0.190	0.1697	0.0038	0.1735	0.1562	0.0034	0.1596
12	28	0.216	0.1928	0.0043	0.1971	0.1773	0.0039	0.1812

All dimensions in inches.
[19]This fit is recommended for nuts only in the numbered sizes.
[20]Basic diameter. Dimensions given are allowable only with tap having theoretically sharp corners. Threaded hole must not reject correct basic "Go" gage by interference with rounded roots due to worn tap. Minimum flat at root equals $1/24 \times p$.
[21]Basic diameter.
[22]The tolerances specified for pitch diameter are cumulative and include all errors of lead and angle.

TABLE 7—FREE FIT (CLASS 2) FOR NUTS IN THE COARSE-THREAD SERIES

Size	Threads per Inch	Minimum Major Diameter[23]	Pitch Diameter			Minor Diameter		
			Minimum[24]	Tolerance[25]	Maximum	Minimum	Tolerance	Maximum
1	64	0.0730	0.0629	0.0019	0.0648	0.0561	0.0017	0.0578
2	56	0.0860	0.0744	0.0020	0.0764	0.0667	0.0019	0.0686
3	48	0.0990	0.0855	0.0022	0.0877	0.0764	0.0023	0.0787
4	40	0.1120	0.0958	0.0024	0.0982	0.0849	0.0027	0.0876
5	40	0.1250	0.1088	0.0024	0.1112	0.0979	0.0027	0.1006
6	32	0.1380	0.1177	0.0027	0.1204	0.1042	0.0034	0.1076
8	32	0.1640	0.1437	0.0027	0.1464	0.1302	0.0034	0.1336
10	24	0.1900	0.1629	0.0033	0.1662	0.1449	0.0045	0.1494
12	24	0.2160	0.1889	0.0033	0.1922	0.1709	0.0045	0.1754
¼	20	0.2500	0.2175	0.0036	0.2211	0.1959	0.0054	0.2013
5/16	18	0.3125	0.2764	0.0041	0.2805	0.2524	0.0060	0.2584
3/8	16	0.3750	0.3344	0.0045	0.3389	0.3073	0.0068	0.3141
7/16	14	0.4375	0.3911	0.0049	0.3960	0.3602	0.0077	0.3679
½	13	0.5000	0.4500	0.0052	0.4552	0.4167	0.0084	0.4251
9/16	12	0.5625	0.5084	0.0056	0.5140	0.4723	0.0090	0.4813
5/8	11	0.6250	0.5660	0.0059	0.5719	0.5266	0.0098	0.5364
¾	10	0.7500	0.6850	0.0064	0.6914	0.6417	0.0109	0.6526
7/8	9	0.8750	0.8028	0.0070	0.8098	0.7547	0.0120	0.7667
1	8	1.0000	0.9188	0.0076	0.9264	0.8647	0.0135	0.8782
1⅛	7	1.1250	1.0322	0.0085	1.0407	0.9704	0.0154	0.9858
1¼	7	1.2500	1.1572	0.0085	1.1657	1.0954	0.0154	1.1108
1⅜	6	1.5000	1.5917	0.0101	1.4018	1.3196	0.0180	1.3376
1¾	5	1.7500	1.6201	0.0116	1.6317	1.5335	0.0216	1.5551
2	4½	2.0000	1.8557	0.0127	1.8684	1.7594	0.0241	1.7835
2¼	4½	2.2500	2.1057	0.0127	2.1184	2.0094	0.0241	2.0335
2½	4	2.5000	2.3376	0.0140	2.3516	2.2294	0.0270	2.2564
2¾	4	2.7500	2.5876	0.0140	2.6016	2.4794	0.0270	2.5064
3	4	3.0000	2.8376	0.0140	2.8516	2.7294	0.0270	2.7564

All dimensions in inches.

[23]Basic diameter. Dimensions given are allowable only with tap having theoretically sharp corners. Threaded hole must not reject correct basic "Go" gage by interference with rounded roots due to worn tap. Minimum flat at root equals $1/24 \times p$.

[24]Basic diameter.

[25]The tolerances specified for pitch diameter are cumulative and include all errors of lead and angle.

TABLE 8—MEDIUM FIT (CLASS 3) FOR SCREWS IN THE COARSE-THREAD SERIES

Size	Threads per Inch	Major Diameter			Pitch Diameter			Maximum[26] Minor Diameter
		Maximum[26]	Tolerance	Minimum	Maximum[26]	Tolerance[27]	Minimum	
1	64	0.0730	0.0038	0.0692	0.0629	0.0014	0.0615	0.0538
2	56	0.0860	0.0040	0.0820	0.0744	0.0015	0.0729	0.0641
3	48	0.0990	0.0044	0.0946	0.0855	0.0016	0.0839	0.0754
4	40	0.1120	0.0048	0.1072	0.0958	0.0017	0.0941	0.0813
5	40	0.1250	0.0048	0.1202	0.1088	0.0017	0.1071	0.0943
6	32	0.1380	0.0054	0.1326	0.1177	0.0019	0.1158	0.0997
8	32	0.1640	0.0054	0.1586	0.1437	0.0019	0.1418	0.1257
10	24	0.1900	0.0066	0.1834	0.1629	0.0024	0.1605	0.1389
12	24	0.2160	0.0066	0.2094	0.1889	0.0024	0.1865	0.1649
¼	20	0.2500	0.0072	0.2428	0.2175	0.0026	0.2149	0.1887
5/16	18	0.3125	0.0082	0.3043	0.2764	0.0030	0.2734	0.2443
3/8	16	0.3750	0.0090	0.3660	0.3344	0.0032	0.3312	0.2983
7/16	14	0.4375	0.0098	0.4277	0.3911	0.0036	0.3873	0.3499
½	13	0.5000	0.0104	0.4896	0.4500	0.0037	0.4463	0.4056
9/16	12	0.5625	0.0112	0.5513	0.5084	0.0040	0.5044	0.4603
5/8	11	0.6250	0.0118	0.6132	0.5660	0.0042	0.5618	0.5135
¾	10	0.7500	0.0128	0.7372	0.6850	0.0045	0.6805	0.6273
7/8	9	0.8750	0.0140	0.8610	0.8028	0.0049	0.7979	0.7387
1	8	1.0000	0.0152	0.9848	0.9188	0.0054	0.9134	0.8466
1⅛	7	1.1250	0.0170	1.1030	1.0322	0.0059	1.0263	0.9497
1¼	7	1.2500	0.0170	1.2330	1.1572	0.0059	1.1513	1.0747
1⅜	6	1.5000	0.0202	1.4798	1.3917	0.0071	1.3846	1.2955
1¾	5	1.7500	0.0232	1.7268	1.6201	0.0082	1.6119	1.5046
2	4½	2.0000	0.0254	1.9746	1.8557	0.0089	1.8468	1.7274
2¼	4½	2.2500	0.0254	2.2246	2.1057	0.0089	2.0968	1.9774
2½	4	2.5000	0.0280	2.4720	2.3376	0.0097	2.3279	2.1933
2¾	4	2.7500	0.0280	2.7220	2.5876	0.0097	2.5779	2.4433
3	4	3.0000	0.0280	2.9720	2.8376	0.0097	2.8279	2.6933

All dimensions in inches.

[26]Basic diameter.

[27]Dimensions given are figured to the intersection of the worn tool arc with a centerline through crest and root.

[28]The tolerances specified for pitch diameter are cumulative and include all errors of lead and angle. Minimum flat at root equals $1/6 \times p$.

TABLE 9—MEDIUM FIT (CLASS 3) FOR NUTS IN THE COARSE-THREAD SERIES

Size	Threads per Inch	Minimum Major Diameter[29]	Pitch Diameter			Minor Diameter		
			Minimum[30]	Tolerance[31]	Maximum	Minimum	Tolerance	Maximum
1	64	0.0730	0.0629	0.0014	0.0643	0.0561	0.0017	0.0578
2	56	0.0860	0.0744	0.0015	0.0759	0.0667	0.0019	0.0686
3	48	0.0990	0.0855	0.0016	0.0871	0.0764	0.0023	0.0787
4	40	0.1120	0.0958	0.0017	0.0975	0.0849	0.0027	0.0876
5	40	0.1250	0.1088	0.0017	0.1105	0.0979	0.0027	0.1006
6	32	0.1380	0.1177	0.0019	0.1196	0.1042	0.0034	0.1076
8	32	0.1640	0.1437	0.0019	0.1456	0.1302	0.0034	0.1336
10	24	0.1900	0.1629	0.0024	0.1653	0.1449	0.0045	0.1494
12	24	0.2160	0.1889	0.0024	0.1913	0.1709	0.0045	0.1754
¼	20	0.2500	0.2175	0.0026	0.2201	0.1959	0.0054	0.2013
5/16	18	0.3125	0.2764	0.0030	0.2794	0.2524	0.0060	0.2584
3/8	16	0.3750	0.3344	0.0032	0.3376	0.3073	0.0068	0.3141
7/16	14	0.4375	0.3911	0.0036	0.3947	0.3602	0.0077	0.3679
½	13	0.5000	0.4500	0.0037	0.4537	0.4167	0.0084	0.4251
9/16	12	0.5625	0.5084	0.0040	0.5124	0.4723	0.0090	0.4813
5/8	11	0.6250	0.5660	0.0042	0.5702	0.5266	0.0098	0.5364
¾	10	0.7500	0.6850	0.0045	0.6895	0.6417	0.0109	0.6526
7/8	9	0.8750	0.8028	0.0049	0.8077	0.7547	0.0120	0.7667
1	8	1.0000	0.9188	0.0054	0.9242	0.8647	0.0135	0.8782
1⅛	7	1.1250	1.0322	0.0059	1.0381	0.9704	0.0154	0.9858
1¼	7	1.2500	1.1572	0.0059	1.1631	1.0954	0.0154	1.1108
1⅜	6	1.5000	1.3917	0.0071	1.3988	1.3196	0.0180	1.3376
1¾	5	1.7500	1.6201	0.0082	1.6283	1.5335	0.0216	1.5551
2	4½	2.0000	1.8557	0.0089	1.8646	1.7594	0.0241	1.7835
2¼	4½	2.2500	2.1057	0.0089	2.1146	2.0094	0.0241	2.0335
2½	4	2.5000	2.3376	0.0097	2.3473	2.2294	0.0270	2.2564
2¾	4	2.7500	2.5876	0.0097	2.5973	2.4794	0.0270	2.5064
3	4	3.0000	2.8376	0.0097	2.8473	2.7294	0.0270	2.7564

All dimensions in inches.

[29]Basic diameter. Dimensions given are allowable only with tap having theoretically sharp corners. Threaded hole must not reject correct basic "Go" gage by interference with rounded roots due to worn tap. Minimum flat at root equals $1/24 \times p$.

[30]Basic diameter.

[31]The tolerances specified for pitch diameter are cumulative and include all errors of lead and angle.

TABLE 10—CLOSE FIT (CLASS 4) FOR SCREWS IN THE COARSE-THREAD SERIES

Size	Threads per Inch	Major Diameter			Pitch Diameter			Maximum[34] Minor Diameter
		Maximum[32]	Tolerance	Minimum	Maximum	Tolerance[33]	Minimum	
1	64	0.0730	0.0038	0.0692	0.0630	0.0007	0.0623	0.0538
2	56	0.0860	0.0040	0.0820	0.0746	0.0007	0.0739	0.0641
3	48	0.0990	0.0044	0.0946	0.0857	0.0008	0.0849	0.0754
4	40	0.1120	0.0048	0.1072	0.0960	0.0009	0.0951	0.0813
5	40	0.1250	0.0048	0.1202	0.1090	0.0009	0.1081	0.0943
6	32	0.1380	0.0054	0.1326	0.1179	0.0010	0.1169	0.0997
8	32	0.1640	0.0054	0.1586	0.1439	0.0010	0.1429	0.1257
10	24	0.1900	0.0066	0.1834	0.1632	0.0012	0.1620	0.1389
12	24	0.2160	0.0066	0.2094	0.1892	0.0012	0.1880	0.1649
¼	20	0.2500	0.0072	0.2428	0.2178	0.0013	0.2165	0.1887
5/16	18	0.3125	0.0082	0.3043	0.2767	0.0015	0.2752	0.2443
3/8	16	0.3750	0.0090	0.3660	0.3348	0.0016	0.3332	0.2983
7/16	14	0.4375	0.0098	0.4277	0.3915	0.0018	0.3897	0.3499
½	13	0.5000	0.0104	0.4896	0.4504	0.0019	0.4485	0.4056
9/16	12	0.5625	0.0112	0.5513	0.5089	0.0020	0.5069	0.4603
5/8	11	0.6250	0.0118	0.6132	0.5665	0.0021	0.5644	0.5135
¾	10	0.7500	0.0128	0.7372	0.6856	0.0023	0.6833	0.6273
7/8	9	0.8750	0.0140	0.8610	0.8034	0.0024	0.8010	0.7387
1	8	1.0000	0.0152	0.9848	0.9195	0.0027	0.9168	0.8466
1⅛	7	1.1250	0.0170	1.1080	1.0330	0.0030	1.0300	0.9497
1¼	7	1.2500	0.0170	1.2330	1.1580	0.0030	1.1550	1.0747
1⅜	6	1.5000	0.0202	1.4798	1.3926	0.0036	1.3890	1.2955
1¾	5	1.7500	0.0232	1.7268	1.6211	0.0041	1.6170	1.5046
2	4½	2.0000	0.0254	1.9746	1.8568	0.0044	1.8524	1.7274
2¼	4½	2.2500	0.0254	2.2246	2.1068	0.0044	2.1024	1.9774
2½	4	2.5000	0.0280	2.4720	2.3389	0.0048	2.3341	2.1933
2¾	4	2.7500	0.0280	2.7220	2.5889	0.0048	2.5841	2.4433
3	4	3.0000	0.0280	2.9720	2.8389	0.0048	2.8341	2.6933

All dimensions in inches.

[32]Basic diameter.

[33]The tolerances specified for pitch diameter are cumulative and include all errors of lead and angle.

[34]Dimensions given are figured to the intersection of the worn tool arc with a centerline through crest and root. Minimum flat at root equals $1/4 \times p$.

TABLE 11—CLOSE FIT (CLASS 4) FOR NUTS IN THE COARSE-THREAD SERIES

Size	Threads per Inch	Minimum Major Diameter[35]	Pitch Diameter			Minor Diameter		
			Minimum[36]	Tolerance[37]	Maximum	Minimum	Tolerance	Maximum
¼	20	0.2500	0.2175	0.0013	0.2188	0.1959	0.0054	0.2013
5/16	18	0.3125	0.2764	0.0015	0.2779	0.2524	0.0060	0.2584
3/8	16	0.3750	0.3344	0.0016	0.3360	0.3073	0.0068	0.3141
7/16	14	0.4374	0.3911	0.0018	0.3929	0.3602	0.0077	0.3679
½	13	0.5000	0.4500	0.0019	0.4519	0.4167	0.0084	0.4251
9/16	12	0.5625	0.5084	0.0020	0.5104	0.4723	0.0090	0.4813
5/8	11	0.6250	0.5660	0.0021	0.5681	0.5266	0.0098	0.5364
¾	10	0.7500	0.6850	0.0023	0.6873	0.6417	0.0109	0.6526
⅞	9	0.8750	0.8028	0.0024	0.8052	0.7547	0.0120	0.7667
1	8	1.0000	0.9188	0.0027	0.9215	0.8647	0.0135	0.8782
1⅛	7	1.1250	1.0322	0.0030	1.0352	0.9704	0.0154	0.9858
1¼	7	1.2500	1.1572	0.0030	1.1602	1.0954	0.0154	1.1108
1⅜	6	1.5000	1.3917	0.0036	1.3953	1.3196	0.0180	1.3376
1¾	5	1.7500	1.6201	0.0041	1.6242	1.5335	0.0216	1.5551
2	4½	2.0000	1.8557	0.0044	1.8601	1.7594	0.0241	1.7835
2¼	4½	2.2500	2.1057	0.0044	2.1101	2.0094	0.0241	2.0335
2½	4	2.5000	2.3376	0.0048	2.3424	2.2294	0.0270	2.2564
2¾	4	2.7500	2.5876	0.0048	2.5924	2.4794	0.0270	2.5064
3	4	3.0000	2.8376	0.0048	2.8424	2.7294	0.0270	2.7564

All dimensions in inches.

[35]Basic diameter. Dimensions given are allowable only with tap having theoretically sharp corners. Threaded hole must not reject correct basic "Go" gage by interference with rounded roots due to worn tap. Minimum flat at root equals $1/24 \times p$.

[36]Basic diameter.

[37]The tolerances specified for pitch diameter are cumulative and include all errors of lead and angle.

TABLE 12—MEDIUM FIT (CLASS 3) FOR SCREWS IN THE FINE-THREAD SERIES

Size	Threads per Inch	Major Diameter			Pitch Diameter			Maximum Minor Diameter[40]
		Maximum[38]	Tolerance	Minimum	Maximum[38]	Tolerance[39]	Minimum	
0	80	0.0600	0.0034	0.0566	0.0519	0.0013	0.0506	0.0447
1	72	0.0730	0.0036	0.0694	0.0640	0.0013	0.0627	0.0560
2	64	0.0860	0.0038	0.0822	0.0759	0.0014	0.0745	0.0668
3	56	0.0990	0.0040	0.0950	0.0874	0.0015	0.0859	0.0771
4	48	0.1120	0.0044	0.1076	0.0985	0.0016	0.0969	0.0864
5	44	0.1250	0.0046	0.1204	0.1102	0.0016	0.1086	0.0971
6	40	0.1380	0.0048	0.1332	0.1218	0.0017	0.1201	0.1073
8	36	0.1640	0.0050	0.1590	0.1460	0.0018	0.1442	0.1299
10	32	0.1900	0.0054	0.1846	0.1697	0.0019	0.1678	0.1517
12	28	0.2160	0.0062	0.2098	0.1928	0.0022	0.1906	0.1722
¼	28	0.2500	0.0062	0.2438	0.2268	0.0022	0.2246	0.2062
5/16	24	0.3125	0.0066	0.3059	0.2854	0.0024	0.2830	0.2614
3/8	24	0.3750	0.0066	0.3684	0.3479	0.0024	0.3455	0.3239
7/16	20	0.4375	0.0072	0.4303	0.4050	0.0026	0.4024	0.3762
½	20	0.5000	0.0072	0.4928	0.4675	0.0026	0.4649	0.4387
9/16	18	0.5625	0.0082	0.5543	0.5264	0.0030	0.5234	0.4943
5/8	18	0.6250	0.0082	0.6168	0.5889	0.0030	0.5859	0.5568
11/16	16	0.7500	0.0090	0.7410	0.7094	0.0032	0.7062	0.6733
⅞	14	0.8750	0.0098	0.8652	0.8286	0.0036	0.8250	0.7874
1	14	1.0000	0.0098	0.9902	0.9536	0.0036	0.9500	0.9124
1⅛	12	1.1250	0.0112	1.1138	1.0709	0.0040	1.0669	1.0228
1¼	12	1.2500	0.0112	1.2388	1.1959	0.0040	1.1919	1.1478
1½	12	1.5000	0.0112	1.4888	1.4459	0.0040	1.4419	1.3978

All dimensions in inches.

[38]Basic diameter.

[39]The tolerances specified for pitch diameter are cumulative and include all errors of lead and angle.

[40]Dimensions given are figured to the intersection of the worn tool arc with a center line through crest and root. Minimum flat at root equals $1/24 \times p$.

TABLE 13—MEDIUM FIT (CLASS 3) FOR NUTS IN THE FINE-THREAD SERIES

Size	Threads per Inch	Minimum Major Diameter[41]	Pitch Diameter			Minor Diameter		
			Minimum[42]	Tolerance[43]	Maximum	Minimum	Tolerance	Maximum
0	80	0.0600	0.0519	0.0013	0.0532	0.0465	0.0013	0.0478
1	72	0.0730	0.0640	0.0013	0.0653	0.0580	0.0015	0.0595
2	64	0.0860	0.0759	0.0014	0.0773	0.0691	0.0017	0.0708
3	56	0.0990	0.0874	0.0015	0.0889	0.0797	0.0019	0.0816
4	48	0.1120	0.0985	0.0016	0.1001	0.0894	0.0023	0.0917
5	44	0.1250	0.1102	0.0016	0.1118	0.1004	0.0025	0.1029
6	40	0.1380	0.1218	0.0017	0.1235	0.1109	0.0027	0.1136
8	36	0.1640	0.1460	0.0018	0.1478	0.1339	0.0030	0.1369
10	32	0.1900	0.1697	0.0019	0.1716	0.1562	0.0034	0.1596
12	28	0.2160	0.1928	0.0022	0.1950	0.1773	0.0039	0.1812
¼	28	0.2500	0.2268	0.0022	0.2290	0.2113	0.0039	0.2152
5/16	24	0.3125	0.2854	0.0024	0.2878	0.2674	0.0045	0.2719
3/8	24	0.3750	0.3479	0.0024	0.3503	0.3299	0.0045	0.3344
7/16	20	0.4375	0.4050	0.0026	0.4076	0.3834	0.0054	0.3888
½	20	0.5000	0.4675	0.0026	0.4701	0.4459	0.0054	0.4513
9/16	18	0.5625	0.5264	0.0030	0.5294	0.5024	0.0060	0.5084
5/8	18	0.6250	0.5889	0.0030	0.5919	0.5649	0.0060	0.5709
¾	16	0.7500	0.7094	0.0032	0.7126	0.6823	0.0068	0.6891
⅞	14	0.8750	0.8286	0.0036	0.8322	0.7977	0.0077	0.8054
1	14	1.0000	0.9536	0.0036	0.9572	0.9227	0.0077	0.9304
1⅛	12	1.1250	1.0709	0.0040	1.0749	1.0348	0.0090	1.0438
1¼	12	1.2500	1.1959	0.0040	1.1999	1.1598	0.0090	1.1688
1½	12	1.5000	1.4459	0.0040	1.4499	1.4098	0.0090	1.4188

All dimensions in inches.

[41]Basic diameter. Dimensions given are allowable only with tap having theoretically sharp corners. Threaded hole must not reject correct basic "Go" gage by interference with rounded roots due to worn tap. Minimum flat at root equals $1/24 \times p$.

[42]Basic diameter.

[43]The tolerances specified for pitch diameter are cumulative and include all errors of lead and angle.

DIMENSIONAL TOLERANCES

Appreciating the importance of proper dimensioning and expression of tolerances in connection with dimensional standards, the Council appointed a special committee early last year to establish a guide to uniform practice. Earle Buckingham, chairman of the special committee, prepared a comprehensive review of the situation with regard to present practice in this connection, together with a definite recommendation which was approved by the other members of his Committee. This review was printed in the October, 1923, issue of THE JOURNAL, on p. 339.

At our September meeting this review was carefully discussed and it was considered desirable that the Screw-Threads Division should propose the accompanying method of expressing tolerances for all S.A.E. Standards, based on Mr. Buckingham's recommendation, for publication in the S.A.E. HANDBOOK, as General Information. As stated in Mr. Buckingham's original review, the subject of tolerances is now being widely discussed in the United States and abroad, particularly with reference to the use of the unilateral or the bilateral system and their application to various standards that are in course of preparation.

Proposed General Information for Dimensional Tolerances

Tolerances are necessary in commercial specifications only because of inability to produce absolutely identical parts. Tolerances should show the permissible amount of variation and the direction of such variation that is less dangerous. When a variation in either direction is equally dangerous, a bilateral tolerance should be given. When a variation in one direction is more dangerous than a variation in another, a unilateral tolerance should be given in the less dangerous direction.

For non-mating surfaces, or atmospheric fits, the tolerances may be bilateral or unilateral, depending entirely upon the nature of the variations that develop in manufacture.

On mating surfaces, with but few exceptions, the tolerances should be unilateral.

The minimum hole should be of basic size in all cases where the use of standard tools represents the greatest economy.

The maximum shaft should be of basic size in all cases where the use of standard purchased material without further machining, even though special tools are required to machine the mating part, represents the greatest economy.

Where tolerances are required on the dimensions between holes, usually they should be bilateral, as variation in either direction is usually equally dangerous. The variation in the distance between shafts carrying gears, however, should always be unilateral and plus; otherwise the gears might run too tight. A slight increase in the backlash between gears is seldom of much importance.

One exception to the use of unilateral tolerances on mating surfaces occurs when tapers are involved. In such cases either bilateral or unilateral tolerances may prove advisable, depending upon conditions. These should be determined in the same manner as the tolerances on the distances between holes. When a variation either in or out of the position of the mating taper surfaces is equally dangerous, the tolerances should be bilateral. When a variation in one direction is of less danger than a variation in the opposite direction, the

tolerance should be unilateral and in the less dangerous direction.

METHODS OF EXPRESSING TOLERANCES

The nominal dimension may be given as a decimal or a common fraction.

When unilateral tolerances are used, one of the three following methods should be used to express them:

(1) Specify limiting dimensions only as

Diameter of hole, 2.250
2.252
Diameter of shaft, 2.249
2.247

(2) One limiting size may be specified with its tolerances, as

Diameter of hole, 2.250 +0.002 −0.000
Diameter of shaft, 2.249 +0.000 −0.002

(3) The nominal size may be specified for both parts, with a notation showing both allowance and tolerance, as

Diameter of hole, 2¼ +0.002 −0.000
Diameter of shaft, 2¼ −0.001 −0.003

Bilateral tolerances should be specified as such, usually with plus and minus tolerances of equal amount. In general, if a greater tolerance is permissible in one direction than in the opposite direction, it is very strong evidence that a bilateral tolerance is not the proper one. An example of the expression of a bilateral tolerance is as follows:

¾ ±1/32 ½ ±0.005

CARRIAGE BOLTS

The Division considered this subject in 1920 and formulated a tentative specification before the present Sectional Committee on Bolt, Nut and Rivet Proportions, sponsored by the American Society of Mechanical Engineers and the Society was organized to handle the subject. The Division since that time has kept in close touch with the work through representation on the Sectional Committee, and is therefore in a position to recommend for adoption, as Tentative American Standards, the accompanying carriage-bolt dimensions proposed in the report of the Sectional Committee.

The work now in progress, and receiving the attention of the Division, is:

(1) Specific applications of the Screw-Threads Specifications to existing and future S.A.E. Standards
(2) Study of Tire-Valve Screw-Threads
(3) Checking of Spark-Plug Screw-Threads with reference to limits and tolerances
(4) Formulation of a specification for plain and slotted high nuts
(5) Formulating a General Screw-Thread Specification

E. H. EHRMAN, Chairman.

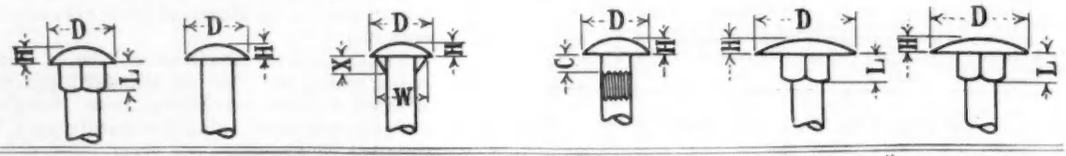
TIRE AND RIM DIVISION REPORT

J. G. VINCENT

In January, 1922, a special committee, consisting of representatives of the Rubber Association of America, the National Automobile Chamber of Commerce and the Society of Automotive Engineers prepared a report to the Standards Committee covering a revised standard list of pneumatic tires and rims. This report was not acted upon at the January, 1922, meeting of the Standards Committee, however, because it was withdrawn upon the request of a committee of representatives of tire companies, just prior to the time of Standards Committee Meeting to allow that committee time to prepare and submit to the Society a recommendation that it thought would represent desired practice for a longer time to come.

As no report was received from the committee since that time the Society has endeavored to determine upon a standardization procedure that would be satisfactory to the various organizations interested in tire and rim matters. Believing that it would be advisable for the Society to have a Division that might represent the tire users in tire standardization matters in the meantime, the Tire and Rim Division was reappointed in April, 1922.

Proposed S.A.E. Standard and American Standard for Carriage Bolts



Diameter of Bolt	Common Carriage			Button-Head Carriage		Fin-Neck Carriage				Ribbed Carriage			Elevator Bolt			Step Bolt		
	D	*H*	*L*	*D*	*H*	*D*	*H*	*X*	*W*	*D*	*H*	*C*	*D*	*H*	*L*	*D*	*H*	*L*
5/16	7/16	3/32	3/16	7/16	3/32	15/32	5/64	5/64	3/8	7/16	3/32	1/8	11/16	3/32	3/16	5/8	3/32	3/16
1/4	9/16	1/8	7/32	9/16	1/8	19/32	7/64	3/32	7/16	9/16	1/8	1/8	7/8	1/8	7/32	13/16	1/8	7/32
5/16	11/16	5/32	1/4	11/16	5/32	23/32	9/64	1/8	17/32	11/16	5/32	5/16	1 1/16	5/32	1/4	1	5/32	1/4
3/8	13/16	3/16	9/32	13/16	3/16	27/32	11/64	9/64	5/8	13/16	3/16	3/16	1 1/4	3/16	9/32	1 3/16	3/16	9/32
7/16	15/16	7/32	5/16	15/16	7/32	31/32	13/64	11/64	23/32	15/16	7/32	1/4	.....	.....	.....	1 3/8	7/32	5/16
1/2	1 1/16	1/4	11/32	1 1/16	1/4	1 3/32	15/64	5/16	13/16	1 1/16	1/4	1/4	.....	.....	.....	1 9/16	1/4	11/32
9/16	1 3/16	9/32	3/8	1 3/16	9/32	.....	.....	.....	.....	1 3/16	9/32	5/16	.....	.....	.....	.....	.....	.....
5/8	1 5/16	5/16	13/32	1 5/16	5/16	.....	.....	.....	.....	1 5/16	5/16	5/16	.....	.....	.....	.....	.....	.....
3/4	1 9/16	3/8	15/32	1 9/16	3/8	.....	.....	.....	.....	1 9/16	3/8	3/8	.....	.....	.....	.....	.....	.....
7/8	1 13/16	7/16	17/32	1 13/16	7/16	.....	.....	.....	.....	1 13/16	7/16	3/8	.....	.....	.....	.....	.....	.....
1	2 1/16	1/2	19/32	2 1/16	1/2	.....	.....	.....	.....	2 1/16	1/2	3/8	.....	.....	.....	.....	.....	.....

All dimensions in inches.

Although no agreement has been reached as to standardization procedure in tire and rim matters outside of the regular Society standardization procedure, the Tire and Rim Division has considered it vitally necessary to revise the most important tire and rim standards now contained in the S.A.E. HANDBOOK. At a meeting held last September in Cleveland, all of the existing tire and rim standards were reviewed and definite revisions thereof suggested. In many cases it has been considered desirable to revise the S.A.E. Standards and Recommended Practices to conform to the standards of the Tire and Rim Association of America, especially in the case of those standards that relate to details of design that do not affect interchangeability of tires, rims and wheels.

PNEUMATIC TIRES

A review of the recommendation made by the Division in January, 1922, indicates that, with the addition of 31 x 4-in. size without an oversize, the list would include enough of the large-production sizes to provide a suitable range for practically all passenger-car requirements. The present standard thus revised is given in the accompanying table.

Proposed S.A.E. Standard of Pneumatic Tires

Type	Nominal Rim		Nominal Tires		Tire-Seat Diameter, In.
	Size	Type	Regular	Oversize	
Passenger Cars	30x3½	C	30x3½	31x4	23
	30x3½	SS	....	31x4	23
	31x4	SS	31x4	....	23
	32x4	SS	32x4	33x4½	24
	32x4½	SS	32x4½	33x5	23
	34x4½	SS	34x4½	35x5	25
Motor Trucks	34x5	SS	34x5	36x6	24
	36x6	SS	36x6	38x7	24
	38x7	SS	38x7	40x8	24
	40x8	SS	40x8	42x9	24
	44x10	SS	44x10	....	24

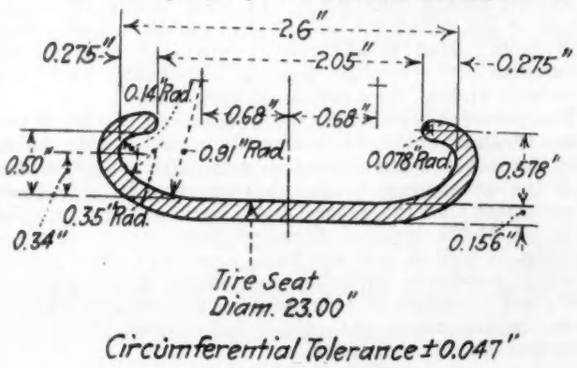
C—Clincher Type.
SS—Straight-Side Type.

PNEUMATIC-TIRE RIMS

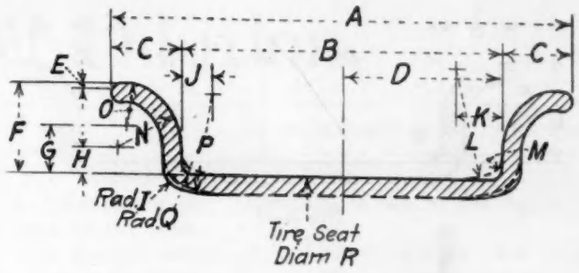
As the present S.A.E. Standard for Pneumatic-Tire Rim-Sections pertains only to interchangeability of tires and rims, it has been considered advisable to revise the standard to agree with the standard dimensions of the Tire and Rim Association of America. The revisions necessary to obtain agreement of these standards are few in view of the fact that the present S.A.E. Standard was developed in cooperation with the Tire and Rim Association.

The dimensions revised as proposed are given in the accompanying tables, but it should be noted that the dimensions for the S.A.E. Standard tire-valve hole in passenger-car rims are retained unchanged as no corresponding standard has been adopted by the Tire and Rim Association of America.

Revised S.A.E. Standard for Pneumatic-Tire Rim-Sections Proposed by Tire and Rim Division

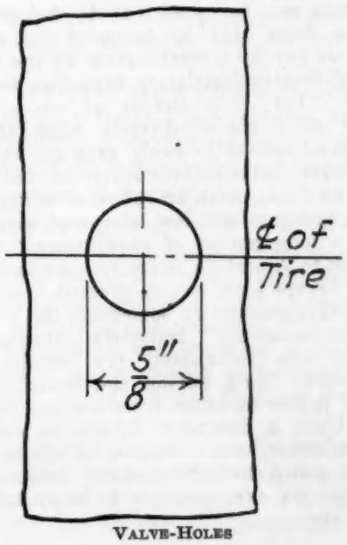


CLINCHER RIM FOR PASSENGER CARS

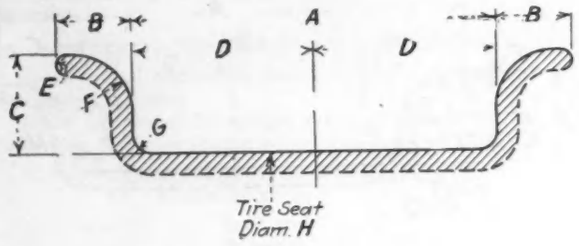


STRAIGHT-SIDE RIMS FOR PASSENGER CARS

	Nominal Rim Sizes, In.			Tolerances, In.
	3½	4	4½	
A	3.432	3.888	4.380	
B	2.313	2.688	3.120	±0.063
C	0.560	0.600	0.630	
D	1.156	1.344	1.560	
E	0.031	0.031	0.031	
F	0.687	0.780	0.875	+0.047 −0.016
G	0.367	0.440	0.495	
H	0.199	0.245	0.303	
I	0.188	0.188	0.188	
J	0.250	0.250	0.313	
K	0.406	0.406	0.406	
L	0.937	0.937	0.937	
M	0.125	0.125	0.125	
N	0.510	0.560	0.615	+0.047 −0.016
O	0.320	0.340	0.380	
P	0.840	0.840	1.095	
Q	0.094	0.094	0.094	
R	23	23, 24	23, 25	



VALVE-HOLES

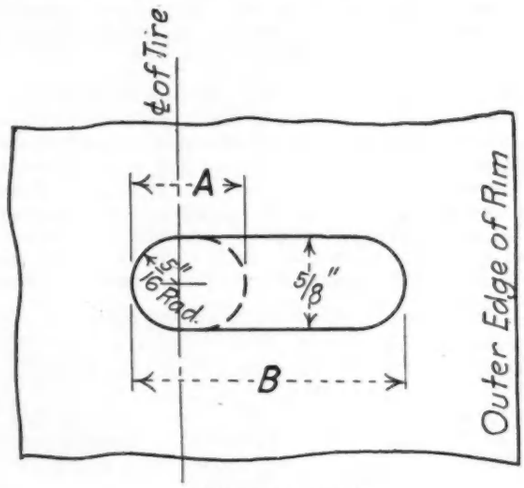


STRAIGHT-SIDE RIMS FOR MOTOR TRUCKS

	Nominal Rim Sizes, In.					Tolerances, In.
	5	6	7	8	10	
A	3.750	4.330	5.000	6.000	7.330	±0.093
B	0.780	1.000	1.000	1.250	1.500	
C	1.063	1.266	1.266	1.500	2.000	±0.125
D	1.875	2.165	2.500	3.000	3.665	
E	0.094	0.140	0.140	0.150	0.188	
F	0.625	0.719	0.719	0.875	1.250	
G	0.250	0.250	0.250	0.313	0.313	
H	24.00	24.00	24.00	24.00	24.00	

Solid-Tire Demountable Rims

The present S.A.E. Recommended Practice for Solid-Tire Demountable Rims, which was adopted in 1918 as a consequence of standardization work for military equipment, has been continued in the S.A.E. HANDBOOK during the last few years owing to the fact that some special equipment was made in accordance therewith. As such rims are now obsolete, it is proposed that this standard be cancelled.



VALVE-HOLE SLOTS

Nominal Rim Size	Present Slot Lengths *A*	Max. Permissible Slot Lengths *B*
5	3/4	1 13/16
6	1 1/8	2 5/16
7	1 1/2	2 5/8
8	1 3/4	3 1/4
10	2 1/8	4 1/8

Deflection and Set Test for Pneumatic-Tire Rims

As the present S.A.E. Standard for Deflection and Set Test for Pneumatic-Tire Rims is of use only in rim manufacture, it should not be continued in the S.A.E. HANDBOOK as an S.A.E. Standard. It is therefore recommended that this standard be cancelled.

J. G. VINCENT, Chairman.

THE WHEAT SITUATION

THE maladjustment between farm prices and prices of other things can be cured (*a*) by bringing other commodity prices down, (*b*) by bringing the prices of farm products up, or (*c*) by a combination of the two. The first method would involve legislation repealing tariff and immigration laws. Very few indeed of our citizens, if this responsibility were placed directly upon their shoulders, would have the boldness to apply such an upsetting remedy in the present unbalanced condition of the world. Such action would no doubt mean an inflow of manufactured goods from adverse exchange and low labor-cost countries at prices that during a long period of readjustment might mean a crushing shock to American industry. At any rate, it would surely deal a severe blow to our present prosperity, and we might soon find ourselves in somewhat the present position of the United Kingdom. Industrial unemployment from which we are now fortunately free would inevitably be greatly increased. Both during the transition period and later, a great inflow of labor from foreign countries would take place. Until a deranged Europe is able to put her house in better order, such measures on our part would seem equivalent to going into "voluntary demoralization." A prosperous America can certainly be more helpful than an unprosperous one.

Taking as a general index basis of 100 the average wholesale prices of a large and representative list of commodities covering the 10-year period from 1905 to 1914 and comparing with it the average prices of the last 3 years, we find the following values for the month of September for the years 1921, 1922 and 1923: 150.6, 163.5, and 164.5 respectively.

During the same period, 1904 to 1915, the weighted money-price of wheat, obtained by averaging No. 2 Red and No. 1 Northern Spring, was 0.978. In other words, in the composite of all values for the 10-year period, wheat averaged 97.8 cents. Had it advanced comparably with all other commodities, the average price in September, 1923, would have been $1.609. As a matter of fact, it was $1.102.

This difference symbolizes the trouble with the wheat situation. If wheat enjoyed anything like a parity with the price level for other commodities, no complaint would be heard from the wheat grower. In this connection it is worthwhile to remember that the general index basis and the 1923 index value of $1.609 included farm products, foods, cloths and clothing, as well as fuel and light, metal and metal products, building materials, chemicals and drugs, house furnishing goods and a number of miscellaneous commodities like cattle feeds, leather, paper and pulp.—C. J. Brand, in *Journal of American Bankers Association.*

Crankcase-Oil Dilution

By E. F. HALLOCK[1]

DAYTON SERVICE MEETING PAPER

PRESENT-DAY fuels are stated to be the cause of crankcase-oil dilution, due to their high end-points, and the author presents tabular data to show how end-points have risen since 1910, together with data showing the effects of various percentages of fuel dilution with relation to the Saybolt viscosities and pour-points of high-grade oils. Three divisions are made of the dilution due to mechanical defects. Contamination, not dilution, necessitates oil drainage, and this statement is elaborated. The rise of heavier-bodied oils is decried.

Six specific divisions of how to avoid crankcase-oil dilution are made and emulsification is discussed, together with demulsibility and crankcase service. Five specifications are made with regard to how to avoid oil-sludging, and carbonization is given lengthy consideration. Proper oil-specification is treated, and instructions on how to avoid oil-pumping and carbon deposit are presented in eight divisions. Why education is needed on the three subjects of how to prevent crankcase-oil dilution, avoidance of oil-sludging and prevention of oil-pumping and carbon formation is explained in conclusion.

ONLY a few years ago, crankcase-oil dilution was practically an unknown and unconsidered subject. Today it is, without exception, the most vital matter in the category of automotive operation and maintenance. The reason for this condition is simple, present-day fuels. The end-point of average fuels for the past few years has gradually risen as indicated by the figures in Table 1, which are typical of average fuels as supplied to service-stations.

TABLE 1—FUELS TYPICAL OF THE AVERAGE QUALITY SUPPLIED TO SERVICE-STATIONS

Year	End-Point, Deg. Fahr.
1910	320
1912	350
1914	390
1918	400
1922	427
1923	438

This high end-point, that is, the intensity of heat necessary to boil off the heaviest portions of the fuel, renders complete evaporation of the fuel a practical impossibility except in the case of engines operating at a constant high temperature.

The appearance of fuel in the crankcase oil is not due to the condensation of vaporized fuel in the combustion-chamber. It is raw fuel that has never been vaporized. Research has shown that mixtures of *vaporized* fuel and air, within the combustible proportions, will remain stable without precipitation at the temperature of the mixture in the cylinders.

The foregoing substantiates the conditions found in servce. In the summer operation of automobiles and in continually hot operating-units the crankcase-oil dilution is nominal, averaging somewhere around 10 per cent. In winter driving, with its periods of frequent idling and generally excessive use of the choke, it is not unusual to find from 25 to 30-per cent dilution after 200 miles of operation or less. Some extreme cases have come to the attention of our laboratory in which the figure was nearer 40 per cent.

The serious effect of the admixture of raw fuel in impairing the lubricating quality of the crankcase oil is, of course, too well known by all people connected with the automotive industry to require much comment. The figures in Table 2 show the effects of various percentages of fuel dilution with relation to the Saybolt viscosities and pour-points of some high-grade oils

TABLE 2—EFFECTS OF VARIOUS PERCENTAGES OF FUEL DILUTION WITH RELATION TO THE SAYBOLT VISCOSITIES AND POUR-POINTS OF HIGH-GRADE OILS

Percentage of Fuel	Flash-Point, Deg. Fahr.	Pour-Point, Deg. Fahr.	Viscosity, Saybolt Sec.		
			104 Deg. Fahr.	140 Deg. Fahr.	210 Deg. Fahr.
Fresh Oil	375	10	254	105	48
2.5	310	5	205	92	47
5.0	...	5	183	87	46
7.5	...	5	162	79	45
10.0	...	0	145	72	43
12.5	...	0	125	66	42
15.0	205	0	108	61	41
17.5	...	0	99	58	40
20.0	...	0	90	54	39
25.0	...	0	74	50	38
Fresh Oil	375	20	500	175	58
2.5	310	15	398	147	54
5.0	...	15	328	124	51
7.5	...	15	264	112	49
10.0	...	10	225	99	46
12.5	...	5	192	98	45
15.0	205	5	164	79	44
17.5	...	0	148	71	43
20.0	...	0	135	64	41
25.0	...	0	102	61	40

From Table 2 it will be seen that even 15 per cent of fuel has the effect of reducing the oil body by an amount equal to a 40-deg. rise in temperature above 104 deg. fahr., and a 25-per cent fuel-content thins the body as much as a 70-deg. increase in temperature of fresh oil above 140 deg. fahr.

The effects of fuel dilution vary with oils of different grades and characteristics, and similar variations are noted in the matter of sludge formation. Other causes of dilution due to mechancial defects, and more difficult of detection, are as follows:

(1) Scored cylinders or poor-fitting rings and pistons

(2) Poor ignition due to dead or fouled spark-plugs, incorrect timing or a weak electrical circuit

(3) Incomplete combustion of the fuel due to an over-rich carbureter adjustment, a flood of raw gasoline caused by the choke or a restricted air-intake to the carbureter or failure to provide a suitable radiator-cover to allow the engine to run warm

The impression is prevalent that the real danger underlying the dilution of the crankcase oil is the loss of lubricating value of the oil itself. For the purpose of emphasizing to the owner the necessity for frequent

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crankcase drainage, we are entirely content to have this impression prevail. However, technically, it is not strictly correct.

Those of us who have studied the problem intently and intensively are agreed that an engine in service will acquire dilution to a limited extent which will vary with the kind of service, the engine characteristics, the condition of the engine and a host of other variables. But beyond that limit any further fuel reaching the crankcase is driven off. We strike a balance, an equilibrium. Speaking in averages, this will be from 10 to 15 per cent of fuel dilution in summer and from 20 to 30 per cent in winter; rarely much over 45 per cent even in extreme cases.

Contamination, Not Dilution, Necessitates Oil Drainage

Such thinning-out of the crankcase oil rouses many misgivings. But, mind you, we are recommending and successfully using for the lubrication of two-stroke-cycle marine-engines a mixture comprising only 1 part of cylinder oil to 40 parts of this same gasoline; 1 pt. of oil to 5 gal. of gasoline! These engines are not pampered. For the most part they are used in fishing dories where they get hour after hour of practically full-load service, day in and day out. And we are using in little high-speed, air-cooled, two-stroke motorcycle-engines mixtures of oil and fuel never more concentrated than 1 part in 8, more often on the order of 1 part in 12 or 1 part in 16, and the resulting lubrication is anything but faulty.

You will appreciate, of course, the reason for the increased wear resulting from the use of the thinned-out crankcase-oil and the satisfactory results accruing to the use of very much thinner mixtures in two-stroke-cycle practice. It is a mere matter of dirt, sediment capable of breaking through the thinned-out oil-film, in one case; and a clean, albeit a thin, oil-film with nothing to rupture it and cause abrasion, in the second instance. I quote in full a letter from H. C. Mougey, control chemist for the General Motors Research Corporation. I feel sure that these data will obviate such misgivings as you may have.

> In reply to your note in regard to the test we made on the Oakland engine using diluted oil, I can give you the following information. This test was made in March, 1921, using an Oakland engine that was built in 1918. The engine was run on the dynamometer at 1500 r.p.m., developing 23 hp. under the conditions of the test. This was not full load. The test was run 130 hr. under these conditions. For the first 60 hr. the lubricant used was a mixture of Standard Oil Co. Junior Red oil mixed with kerosene in the ratio of 60 parts Junior Red oil and 40 parts kerosene by volume. The viscosity of the mixture was 56 Saybolt sec. at 100 deg. fahr. At the end of 60 hr. the lubricant was changed to a mixture of Gerkins F. A. Heavy, diluted with kerosene in the same proportions. The viscosity of this second mixture was 63 Saybolt sec. at 100 deg. fahr.
>
> It was found that under the conditions of the test, instead of the dilution increasing or remaining constant, it actually decreased. For this reason tests were made on the oil in the crankcase from time to time, and diluted oil was used to keep the dilution as near as we could to 40 per cent. The engine performed in a satisfactory manner throughout the entire test but, at the end of 130 hr., the crankcase was allowed to run dry and under these conditions a connecting-rod bearing burned out. The engine was then torn down for examination and found to be in perfect condition except for the bearing that was burned out, two pistons that were scored and the top rings that were stuck in the grooves in these two pistons. All other pistons, cylinder walls, bearings and the like were O. K.
>
> We believe this damage was done in running the engine without oil. The bearings were then replaced and an additional run was made using dirty diluted oil drained from a tractor. The dilution was kept at about the same percentage but the oil contained large amounts of dirt. Under these conditions the bearings and the cylinder walls were very badly scored and abraded by the dirt.
>
> This test showed that it is possible to run an engine with clean diluted oil and that the viscosity we used in this test was sufficient, provided the oil was clean. This test also showed that if the oil was full of dirt, sand, clay and similar materials, an oil of this viscosity did not give a thick enough film to keep the particles of dirt from injuring the bearings, the pistons and the cylinder walls. We have never made tests to determine the size of the dirt particles that can be permitted with different viscosities of oil.
>
> The test described above was run on the dynamometer at room temperature and, under these conditions, we had no water in the crankcase. In actual service we have water mixed with the contents of the crankcase in most of the cars in winter. If this water carries small amounts of sulphuric acid, due to the burning of the sulphur in the fuel, it is possible to have serious corrosion troubles in the crankcase. The fact that water causes trouble in service does not necessarily mean that engines will not operate with water mixed with the lubricating oil; in fact, we made a run at one time on a Delco-Light engine using as a lubricant a mixture of soluble screw-cutting oil and water in the ratio of 1 part soluble oil and 20 parts water. This Delco-Light engine was run at full-load for 1 week, 24 hr. per day, under these conditions. It performed satisfactorily and was in perfect condition at the end of the test.

And so we in the lubrication field, as the result of our experience, advocate drainage of the crankcase frequently, not particularly because the oil becomes diluted, but because the oil becomes contaminated; while it will stand thinning-out alone and still possess ample value to accomplish its primary function of retarding wear, contamination seriously hampers it in this performance.

Use of Heavier-Bodied Oils Decried

Dilution will thin-out an oil and impair its ability to seal the piston-rings, to be sure. But, happily, when the rings are properly fitted, the cylinders are properly finished and the connecting-rods are properly aligned, it does not take an oil of exceptional viscosity to seal the rings adequately at the engine and the piston speeds prevalent in today's practice. Also, the thinned-out oil will be consumed faster. It will reach the combustion-chambers in greater abundance. The practice of going to a heavier-bodied lubricant to counteract dilution is therefore to be decried. It is of doubtful value in accomplishing the purpose for which oil is put into the crankcase. And there is no doubt whatsoever about the greater tendency of the heavier-bodied oil to "stew" down into an objectionable carbon-formation under the temperatures usual in an engine in which dilution is chronic.

The oil recommended by the lubricant refiners' engineers, be it heavy, light or of intermediate grade, possesses ample body to do its work between the periods at which crankcase drainage is recommended if excessive or unusual dilution does not occur. The dilution problem is closely interlocked with the carbon problem, with the "sludging" problem, with the corrosion problem, with lubrication troubles in general. It is hard to treat it alone and do the subject justice.

It would help all of us if, somewhere in your instruction-books and service literature, you found space to drive home with real force the following instructions aimed to minimize the trouble:

How To Avoid Crankcase Dilution

(1) Avoid excessive use of the "choke." After starting give the engine time to warm-up somewhat before driving

(2) Use a radiator cover during winter to allow the engine to warm-up more rapidly and also to run at a higher temperature. A cold running engine acquires dilution much more rapidly than a hot one because all the fuel injected into the cylinders does not burn. Some of it finds its way into the oil-pan. Heat aids vaporization and promotes perfect combustion

(3) Avoid idling for long periods or excessively slow driving. At very low speeds objectionable suction sets in, tending to increase dilution

(4) Keep the engine in good mechanical condition. The oil consumption will indicate whether it is in good condition. An engine in good mechanical condition may be subject to dilution at idling speeds and in city driving, but in cross-country higher-speed service the dilution will be reduced by evaporation of the fuel in the oil. If, however, in both low and high-speed service the oil-level gage does not indicate an apparent consumption, the rate of raw-fuel dilution is reaching a dangerous stage and the only remedy is to have the pistons and the piston-rings refitted. If the cylinders are out-of-round, tapered or scored, have them reground. New rings or pistons alone are not sufficient unless the cylinders are true. *When excessive wear has once set in, the use of a heavier oil will not cure the condition.* In fact, such practice temporarily acts as a narcotic, only to invite trouble of a different nature later on. It is not possible to replace satisfactorily metal that has been worn away with heavy-bodied lubricants

(5) Drain the oil-pan frequently. At least every 1000 miles in summer and every 500 miles in winter is a good rule for average conditions. Replace with the correct grade of fresh oil

(6) Do not flush the crankcase with kerosene. It is impossible to drain all the pockets without dropping the oil-pan. Kerosene that is trapped remains to dilute the fresh oil. Drain the crankcase while the engine is warm and the oil is agitated; this will carry off the sediment. [Some disagree with this statement and believe that flushing with kerosene to remove dirt is desirable except in engines that cannot be well drained.]

Our experience teaches that when draining is neglected, danger accrues not only from the excessive wear that the dirt gives rise to, but also from emulsification or "sludging" of the oil and from corrosion under certain conditions.

Emulsification

The formation of "sludge" in crankcase oil is due to a combination of several causes and is really an emulsion formed by water in the presence of road dirt, carbon dust and minute metal particles such as are always present in an engine crankcase. This condition is possible even with very carefully treated oils having a high demulsibility figure. In general, the average owner does not understand why water accumulates in the engine oil-pan and in some engines more than in others. The condition is not always a fault, but more often a characteristic of the design. A worn engine, however, will generally accumulate more water than a new one.

To appreciate the most common source of water in the engine, it is only necessary to hold a glass tumbler over the end of the muffler pipe and note the rapid collection of water drops condensed from the exhaust. The exhaust gases are saturated with water-vapor and upon striking a colder surface this will condense. The crankcase of an engine, until it becomes thoroughly heated-up, acts as a condenser for all the exhaust gases that pass downward by the pistons. When the crankcase becomes thoroughly warm, the greater portion of such exhaust gases passes on out through the breather. A hot-running engine allows much less water accumulation in the oil-pan than a cold one. Short runs, such as are encountered in city automobile driving, do not allow the engine to heat-up properly and some water in the oil-pan may be expected.

It is practically impossible to prevent the presence of water in the crankcase of an automobile. In fact, in our laboratory work, we have noted the presence of water in a crankcase that was previously cleaned, dried and warmed after operation of only 3-min. duration.

Fire apparatus is the most prolific source of sludging complaints brought to our attention, and the underlying causes of the trouble encountered in this service are interesting and instructive. It is common practice with such apparatus to start the engine up each morning, idle it for a few moments just to see that all is well and ready for the call and then shut it off. Sometimes this daily start is continued for weeks, even months, without the apparatus being called upon for any service that will develop even moderate engine temperature. Then the complaints roll in; "the oil is no good," "it thickens up into a livery mass," "the engine has never been out of the house since fresh oil was added," and so on ad infinitum.

If the oil is fresh and properly refined, the water will not remain in permanent suspension; but as the oil becomes contaminated with particles due to metallic wear, road dirt, free carbon and acidulated moisture resulting from the combustion of fuels with sulphur-content, its ability to separate from the water is lessened.

Demulsibility and Crankcase Service

Table 3 shows the results obtained by using an exceptionally well cleaned-up turbine-oil having a demulsibility value of 500 as against the average value of somewhat over 300 for high-grade automobile oils.

TABLE 3—RESULTS OBTAINED BY USING AN EXCEPTIONALLY WELL CLEANED-UP TURBINE-OIL HAVING A DEMULSIBILITY VALUE OF 500

Details	Samples[a]				
	1	2	3	4	5
Specific Gravity	0.901	0.912	0.904	0.903	0.897
Pour Test, deg. fahr.	40	30	35	35	30
Viscosity, Saybolt sec. at 104 deg. fahr	245	249	245	240	162
Neutralization Value	0.1	0.8	0.6	0.6	0.8
Herschell Demulsibility	500	0	18	20	0
Herschell Demulsibility after Filtering Through Paper	.....	500	800	700	700
Insolubles	.....	0.77	0.15	0.13	0.39
Fuel	.....	5.40	2.00	1.70	1.70

[a] Sample 1, fresh and unused; Sample 2, used for flushing the crankcase previous to the test; Sample 3, after an idling period of 5 min.; Sample 4, after a run through traffic of 1-hr. duration; Sample 5, after a 200-mile run.

The condition of sample No. 2 shows how the addition of a small quantity of carbon and carbonaceous matter has reduced the demulsibility to zero. It will be noted that the relatively high demulsibility-reading on the fresh oil was practically eliminated after being 5 min. in the crankcase, but that it was restored and *bettered* after filtering through paper!

Table 4 exhibits figures that bear on the acquisition of acidity and its effect on the demulsibility of the oil.

TABLE 4—RELATION BETWEEN DEMULSIBILITY AND ACIDITY AND TIME THE OIL IS IN SERVICE

Time in Service		Viscosity, Saybolt Sec.		Demulsibility	Acidity, Per Cent
Days	Months	At 100 Deg. Fahr.	At 150 Deg. Fahr.		
New	Oil	148	68	1,200	0.000
2	....	151	68	130	0.010
.....	2	165	71	78	0.100
.....	3	176	72	76	0.295
.....	9	189	....	81	0.850

Acidity and its bugaboo, corrosion, mainly result from the use of fuels that are sulphur-laden. It is hard to keep the sulphur-content of benzol low, for instance. Many a corrosion complaint is traceable to the frequent and unguarded use of benzol.

Sulphur in the presence of sufficient air burns to sulphur dioxide, SO_2. This has a strong affinity for moisture and when wetted forms sulphurous acid, H_2SO_3, a weak acid, to be sure, when cold, but potent to attack unprotected bright metal parts within the crank-chamber when warmed by the engine heat. This acid in time oxidizes to sulphuric acid, H_2SO_4, which is worse.

Sludge formation has a queer feature that must be carefully watched; else the complaint will become chronic. However, few operators are acquainted with it. Unless the crankcase is perfectly cleansed after sludge has once formed, the trouble will appear again with startling rapidity. Particles of sludge remaining seem to act as catalyzing agents to hasten the emulsification of the new oil. To combat sludging and corrosion evils that, with each winter, seem more pronounced, we would suggest for inclusion in your instruction-books the following:

How to Avoid Oil-Sludging

(1) While the engine is warm, drain off a cupful of oil. If it contains a quantity of water, make it a practice to repeat this operation every 3 or 4 days; and by so doing remove the cause of much worry

(2) Make use of a suitable radiator-cover. It will not only assist in cutting the tendency to sweat in the crankcase but will retard the dilution tendency. Water, if allowed to get into the oil circulating system, will pocket and freeze very readily, causing a tie-up in the circulation. It should be remembered that oil does not freeze. The oil itself should not be condemned when the oiling system ceases to function, if the correct body of good oil is being used. Almost every case is traceable to stoppage by ice or a mechanical fault

(3) Clean the oil-screen regularly, at intervals representing not over 100 hr. of service

(4) The fuel has something to do with water accumulation. High-test gasoline generally gives better satisfaction, as the engine warms-up more quickly

(5) If sludging should occur, make sure that the last trace of the formation is cleaned from the crankcase before refilling. Do not rely on flushing; drop the oil-pan and clean it thoroughly

Carbonization

Also of importance in breeding complaints is carbon, a most annoying, almost exasperating, engine malady. If the people who use automotive engines, the people who service them and even the people who build them faced the question squarely, complaints on the score of carbon deposit would be of far less-frequent occurrence. It is a most natural thing, however, to blame all the carbon faults on the oil, good, bad or indifferent; "it is the oil that is at fault." But is it? Let us look into the subject a little. You know as well as we do that it is essential that we get some oil above the pistons. If we got none, if the rings form a positive barrier, woe-betide the cylinder walls. Technical people have bent every effort to obtain that happy medium in design which will pass enough oil to lubricate, not enough to "oil-pump." The margin between the two conditions is a narrow one. For instance, idle a motor-car engine at the curb for a while; open the throttle and it will smoke for a moment or two. Drive the same car along the road at 30 or 35 m.p.h. and the exhaust will be as clean as a whistle. Under idling conditions it is an oil-pumper; under normal loading it is a properly lubricated engine. What is the difference. Nothing you can control at the factory; it is just a difference in combustion-chamber temperature. At low throttle not enough heat is present to burn clean the amount of oil drawn into the combustion-chambers. Under load, with increased temperatures, we attain clean burning.

With this thought in mind, you will be ready to appreciate why our service engineers cure many of the oil-pumping complaints we get by adjusting the carbureter properly, by adjusting the spark-plug gaps and the breaker-points properly, by regrinding the valves and adjusting the tappet clearances properly; in a word, by bending every effort to maintain that efficiency of combustion which is essential to assure heat enough to burn the excess oil clean.

Unfortunately, a "carbon-free" oil does not exist. All mineral lubricating oils are combinations in varying amounts and forms of hydrogen and carbon and are grouped under the general term hydrocarbon, and our fuels are similiar but simpler in structure. It is a queer thing about such hydrocarbons that under critical conditions of temperature and pressure they become nonstable and disintegrate into simpler hydrocarbon compounds. We call this reaction "cracking"; to achieve it both the temperature and the pressure must be proper.

That in itself is not particularly interesting. But it is interesting to know that whenever we crack a petroleum product, regardless of its molecular structure, *we release one atom of free carbon for every molecule of the substance that is broken-up.* Thus, to follow through a typical case, suppose we start with the product pentadecane, which is a saturated hydrocarbon of the methane series, the chemical formula for which is $C_{15}H_{32}$. Under the influence of heat and pressure that are properly regulated, this hydrocarbon may be "cracked" to form pentane, C_5H_{12}, a saturated hydrocarbon also of the methane series, ethylene, C_2H_4, an unsaturated hydrocarbon of the olefine series and free

or uncombined carbon C. The general scheme of the reaction is

$$C_{15}H_{32} + \text{heat} + \text{pressure} = 2\,C_5H_{12} + 2\,C_2H_4 + C$$

No matter how complex or how simple the structure of the hydrocarbon we start with, if we crack it we always release one atom of carbon for each molecule of the substance cracked. Taking pentane, one of the simpler hydrocarbons resulting from the above reaction, we can crack it again after the following manner:

$$C_5H_{12} + \text{heat} + \text{pressure} = C_2H_4 + 2\,C\,H_4 + C$$

We have still simpler hydrocarbons, and *still we have free carbon.* And, in our engine combustion-chambers we have *heat* plus *pressure* and oil and fuel, both mixtures of various hydrocarbons, some simple, some complex. Cracking is inevitable; the formation of carbon follows as a matter of course.

If the combustion-chamber is not lined with a sticky film of oil stewing down into a tacky mass to catch the carbon and hold it, or if ample heat and a surplus of air are present to effect perfect combustion of the carbon thus released, little or no harm is done. But note what happens when the engine is not kept in shape to promote efficient combustion, when habitual overfilling of the crankcase reservoir is practised, when shims are fitted improperly on pressure-feed systems so that streams of oil are projected into the cylinder bores and when operators go to heavier-bodied, more viscous lubricants than can be properly handled under the prevailing combustion-chamber temperatures to quiet noisy, badly worn engines or to maintain the oil pressure recommended on force-feed jobs where loose bearings permit the lighter-bodied oils to pour out, reducing the oil pressure. Gentlemen, here are your troubles in a nut-shell, and you can correct more of them by proper education than you can by design changes.

Oil Specification

An effective campaign will give the user a clean-cut definite picture of the proper oil to use in terms understandable to the engine operator himself and in terms understood by the garage folk and filling-station attendants on whom the public relies for its supplies of lubricants.

A campaign to eliminate oil-pumping and carbon complaints must start with a definite recommendation of oils of known quality. For, while all oils are hydrocarbons and therefore subject to the carbon-forming tendency mentioned above, it is also true that improperly refined oils may not be totally devoid of free or uncombined carbon when fresh, or may incorporate ingredients or fractions of such a nature that free carbon in abundance develops rapidly in these oils in service. Then, the more viscous oils, however well refined, must be used with care. Being hard to vaporize, when used in engines with low or moderate combustion-chamber temperatures, they stew and gum and collect the tacky film formed by the free carbon released when oil and fuel crack. They are safe for use only in engines in which the combustion-chamber temperatures run high as in aircraft, tractor, air-cooled and Knight-valve engines or in moderately heated engines in which mechanical means make freedom from excessive oil-pumping a certainty, but surely not in worn engines to compensate for piston and cylinder wear or to increase the oil pressure on force-feed jobs where bearing looseness defies the pump to maintain the recommended pressure on the recommended oil.

You can go a long way toward side-stepping trouble of a serious nature by incorporating substantially the following instructions in your instruction-books and service letters.

How to Avoid Oil-Pumping and Carbon Deposit

(1) Use nothing but the highest-quality oil of the body and character exactly suited to engines in average service

(2) Fill the crankcase carefully to the *proper level* daily. Do not overfill. Overfilling causes oil-oiling and carbon formation

(3) If our instructions on maintenance are carried out, you can expect many thousands of miles of service before appreciable cylinder-wall and piston wear takes place. When such wear occurs, have the cylinder-block reground and oversize pistons fitted. Do not attempt to compensate for wear by using a heavier-bodied oil than has been recommended. The indiscriminate use of heavy-bodied lubricants is a most frequent cause of fouling spark-plugs, sticking valves, prolific carbon-formation and "carbon knock" or detonation. Avoid it

(4) Do not shift to a heavier-bodied oil than has been recommended to increase the oil pressure. If the oil pressure falls off gradually, the most likely cause is badly worn bearings, permitting an excessive bleed. You cannot correct this with heavier oil or by setting the pressure-relief valve to maintain higher pressures. Both of these attempts to bolster-up the oil pressure lead to excessive carbon-formation. If the oil pressure is not what it should be, investigate and find out the cause and correct that; do not disturb the adjustment of the relief valve or change to a heavier-bodied oil

(5) When the bearings are tightened be sure that the shims, as well as the bearings themselves, are properly fitted to the crankpin. Poor shim-fits are responsible for many complaints of low oil-pressure, oil-pumping and carbon formation

(6) Be sure that your carbureter is properly adjusted. With a rich mixture, carbon forms from the incomplete combustion of both oil and gasoline, and the excess of fuel dilutes the oil

(7) "Missing" promotes both oil-pumping and carbon formation. Therefore, keep the igniter clean and in perfect adjustment; and see to it that the plugs are in good condition, clean and the gaps perfectly adjusted

(8) Compression losses lower the efficiency of combustion and the ability of the burning fuel charge to dispose of excess oil. Therefore keep the valves properly ground-in, the tappets properly adjusted and the pet-cocks and cylinder-head gaskets tight and use the grade or grades of oil recommended to assure adequate sealing of the piston-rings against compression losses

Education Needed on Three Points in Engine-Lubrication Problems

To summarize for the moment, we find that we have three things, three lessons, if you will, to drive home to the car operator; (*a*) how to prevent crankcase dilution, (*b*) how to avoid oil-sludging and (*c*) how to prevent oil-pumping and carbon formation.

It is evident, I believe, to each of us, that if we register these instructions with the motoring public effectively, most of our lubrication problems will be solved. Nothing we can do, even by combining all the forces available to us, will accomplish this mission at a single stroke. Education accrues from constant reiteration of basic facts in diversified forms. We can, with advantage, revamp the lubrication instructions, placed in the hands

of the car-owner when the car is purchased, to conform to this program. This is one of your duties, although we lubrication people will be glad to cooperate with you in drafting your instructions. We can, when this method seems desirable, supplement the regular instruction-book with a fully developed lubrication instruction-book, a book prepared by lubrication engineers in collaboration with your technical people and issued jointly by the collaborators.

We can supplement these thorough instructions with condensed instructions for draining, filling and the correct oil to use, on a plate attached to the crankcase adjacent to the filler or the dash in plain sight when the hood is opened. This method is most effective but should be considered as supplementary to the full instructions issued in printed form.

So much for definite instructions that go out with the car. We cannot assume that our responsibility to the public ends when we have prepared and issued these in some enduring form. They are not always read, and even when read they are not always fully digested or fully appreciated when fed in a single dose. And so the service letter or service bulletin issued periodically plays a big part in bringing about a fuller appreciation of the importance of these teachings, service letters from you to your people and from us to our people, all correctly inflected so that the word reaching the operator is always the same in meaning, despite our several ways of expressing it.

This suggestion might be passed on to the carbureter people and to the ignition people; for the correct adjustment of their apparatus, it has been clearly demonstrated, is very important in the satisfactory solution of our dilution, sludging and carbon problems. And they, like we, can work into their copy some constructive thoughts without lessening its sales appeal. We in the service end of the work should work more closely with our advertising and our publicity people; more often than not we find them wide-open for copy suggestions that are timely and lend themselves to treatment in accordance with their different standards and responsibilities.

Direct talks to the people who use our products, when they are good talks and forcefully presented, do a wonderful amount of good. Much of the educational work we are doing takes the form of illustrated lectures; talks to dealers, to owners, to service people and to people whom we feel can and will profit to a very great extent by talks of this kind.

By and large, we oil people have 10 dealers for each 1 of yours. My own company has 50,000 dealers in daily intimate contact with the people who use your equipment. To your dealers and ours, our mutual customers turn for the latest news, the last word; they are *the* authority to the multitude. If we are to make progress along the educational lines indicated, we must make these men real authorities. We must all teach the same lesson in about the same way.

AMERICAN THRIFT

CASUAL observers charge the American people with being hopelessly profligate in financial matters. They are accused of being wasteful to the point of unintelligence. The fact that in 1923 they were able to absorb nearly 4,000,000 automobiles is being pointed to by critics as a bit of contributing evidence on this subject. Before we adopt such a depressing conclusion regarding the national disposition, we should not overlook, but give due weight to, the significant fact that in the same year the American people paid for new life-insurance to the amount of $11,710,000,000.

This year's record of new life-insurance is conclusive proof of the substantial character of the country's continued prosperity and the increased purchasing power of the American people. This great addition to the personal protection of policyholders' families carries with it the addition of hundreds of millions of dollars to the productive capital of the country through the investment of life-insurance funds and will continue to be one of the strongest factors in maintaining a steady, healthy growth in the nation's commercial life. Funds contributed for life-insurance premiums constitute the greatest single force in keeping the commerce of the nation active and efficient. In addition, the farmer is enabled to cultivate his farm more widely and produce food in greater abundance.

The American Government was founded upon the proposition that the purpose of government is the protection of the individual in the enjoyment of his rights. It does not exist for the purpose of making men successful but to encourage men to make themselves successful by guaranteeing to them the fruits of their labor. This has resulted in the spurring of individual initiative, the fostering of individual ambition and the compelling of individual achievement. As the individual has developed, the nation has grown, because the individual, recognizing that upon his own efforts depends his future, has acquired habits of industry, thrift and foresight which have turned him toward making provision for those naturally dependent upon him. In other words, the American form of constitutional government has been the cause of individual success, which in the aggregate has made for national greatness.—E. D. Duffield, president Prudential Insurance Co. of America.

LARGE-SCALE PRODUCTION

THE limitations on large-scale production arise mainly from the infirmities of human nature. The extension of the scale of operations means an ever-increasing reliance upon hired labor and an ever-lessening reliance on spontaneous self-interest. If all men worked with as much energy and spirit for an employer as they do for themselves, the spread of large-scale production would be almost boundless.

The limitations of men's faculties explain why large-scale operations do not make their way with unfailing certainty. Every new machine, every change to larger scale, involves risks, calls for planning and judgment, is dependent on some individual's initiative. If an indefinite number of individuals were capable of this sort of work, the march of progress would be faster and large-scale operations would make their way more surely and speedily. As it is, these changes wait on the impulse given by the comparatively few individuals who have the capacity for industrial leadership.—F. W. Taussig.

Providing the Engineer with Service Data

By O. T. KREUSSER[1]

DAYTON SERVICE MEETING PAPER *Illustrated with* CHART

TO furnish each year better, prompter and less costly service compels the development of field service-branches that operate on a sound business basis such that all the capital involved is applied toward operating all of the floor-space to its maximum capacity, turning-over the stock with the maximum frequency, justifying the existence of the tool equipment and having the right men all pull together. Data are necessary in the conduct of any business on an efficient basis, and the field experience provides a definite channel to bring to the designing and the production organizations the information that is most valuable in making an improved product.

Two tendencies of the industry are toward automobiles that become lower in overall costs per mile of transportation and vehicles that function with less trouble, delay and inconvenience. The author discusses the subject at length under headings of maintenance troubles, field information, recording and charting of service data and cooperation between the factory and the service-men.

WE believe there is no discussion as to the place service must occupy in the selling of automobiles. The customer is already giving the preference, everything else being equal, to the car builders who show evidence that they realize their responsibility to the customer and provide him with the facilities and the attention he may need during the life of his car. That means the service-man must continually broaden his outlook to prepare for the improvements in service that the customer has a right to expect. In other words, we must be prepared to furnish each year better service, prompter service and at a less cost. This, in itself, compels the development of service branches in the field that operate on a sound business basis to the extent that all the capital involved is aiding in obtaining a result; all the floor-space is operating to its maximum capacity; stock on the shelves is turning-over with maximum frequency; tool equipment is justifying its existence and the right men are all pulling together to get a result.

To help the field organizations to meet these conditions and assume these responsibilities gradually, the service manager must begin to open channels to obtain such information as is necessary in the conduct of any business on an efficient basis. One must remember that, to the customer, the annoyance of adjustment and repairs is sometimes just as serious as the cost of repairs and has its reflection in the number of repeat-orders for new cars.

The service experience in the field provides a definite channel to bring to the designing and the production organizations the information that should be most valuable in making an improved product. We must remember that the elimination of unnecessary service due to failures of an avoidable nature is just as important as rendering good service economically at all times.

It would be ideal for the designer to spend a considerable part of his time in the field, each season, in actual contact with the users of his cars. In addition, he should be provided with a prompt and reliable means indicating just what is being done to the cars in all the fields that the service organization represents. As an actual condition, the engineering staff will never get much opportunity to spend time in the field. The every-day production problems, coupled with the continued pressure for new, better and more economical designs, confine the engineer to service experiences that must remain local for the most part. The results obtained with the same car in different sections of the Country vary sufficiently to warrant a very close analysis before the conditions demanding a change of design in an existing product are acted upon.

TENDENCIES OF THE INDUSTRY

History shows clearly two very definite tendencies in the industry. First, the automobiles must become lower in price, that is, lower in overall costs per mile of transportation; this includes first cost, operating cost, service cost, maintenance cost and resale value. Second, the vehicles must function with less trouble, less delay and less inconvenience. Or, to summarize, the continued growth of the automobile industry is predicated on producing individual transportation at less cost with equipment that provides more reliable functioning. For this reason the actual service obtained with cars in the customers' hands today and tomorrow, not 2 or 3 years ago, is of the utmost importance to every manufacturer who is endeavoring to stay in the front rank and produce a vehicle that will give more miles, more convenience and more repeat-orders. The major troubles in the field with one's cars are eventually brought home directly because the customer has learned to insist on a definite performance and demands correction or replacement in the event of serious failures.

MAINTENANCE TROUBLES

As one looks over the detailed records of operation of many different makes of cars in the same service, it becomes apparent that most maintenance troubles are not of a major character but are multiplications of detail troubles. In the case of new models, this may not always be true, as "unknowns" sometimes creep in, giving troubles in the field which are usually remedied individually by campaigning. The average service-department of a car company can furnish a fairly complete list of the number of parts that go out to the different territories. But, unfortunately, the information generally stops there. There is not complete knowledge as to just what attention to the cars is necessary in the field to provide performance that is satisfactory to the customer. The record of parts shipped is not in itself of much value to the engineer inasmuch as it does not give definite facts as to when the parts were used or whether the factory was

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depended upon as the source of supply for all the parts needed in the work. It leaves out the big factor of making repairs and adjustments that do not require new parts.

Field Information

The contact today between service and engineering is not always based upon definite up-to-the-minute knowledge of what is happening in the field so far as adjustments and work carried on by the service-stations are concerned. This condition often results in delaying changes that should be made. Eventually, complaints from the field become so insistent that the design or the material involved is changed; the delay being costly in both expense and good-will. Again, extensive changes are sometimes made, based upon a local condition, which, if all the facts had been known, would not have demanded the particular method of correction followed. The service department, with the contact it has in the field, is in a good position to make available to the engineering and the production departments the exact information pertaining to the equipment in the field and from all points at all times.

It is not argued that the service department should be in a position to supply the detailed information necessary to make an engineering change in design or material, but it should have at all times a record that will act like the signal-system of a railroad, indicating when excessive trouble is experienced in a particular detail or function of the product, as compared with previous experiences.

Usually when we say "record" we get the idea that it involves a volume of detail work, a great amount of which is not of much value. This should not be the case if one keeps clearly in mind the purposes of the record instead of attempting to weigh it down with a mass of detail that, while it might have some remote value in the final count, does not furnish information changing materially the overall picture of the performance of one's product as indicated by a more simple record.

The material shipped to the territory for repair purposes is not a real measure of the work done, as in adjusting and maintaining cars many jobs do not require parts. For this reason the number of parts sold is a poor measure of analyzing what is happening to our product in the field. We must develop a qualitative method to indicate everything of interest.

The satisfactory performance of a motor car from the customer's standpoint is still an unknown quantity; it is based purely upon comparisons. Everyone tolerates the necessity of providing against the freezing of a radiator in winter. Everyone takes it for granted that carbon must be removed at certain intervals. This sort of thing is true until someone comes along with a type of design or construction that eliminates some of the things we have been accustomed to tolerate; then the basis of comparison immediately changes.

Recording Service Data

By assisting the individual garages in the field to develop those records that are most useful in conducting their business in an efficient way, the service departments can help to the extent of providing the field with suitable information and printed material that will make it possible for them to furnish the information to the factory which will in turn be instrumental in making their job more agreeable by providing the customer with a more satisfactory product.

It is very questionable whether a customer who repeatedly comes in for many tinkering types of adjustment is a happy or profitable customer. While the individual charge to him may be small, the aggregate in a year's time is considerable and has weight in the matter of whether or not you sell him another car of your manufacture. If you do not, the service-station loses a customer. It is within the service-station's power to have an ever-increasing number of customers that require little attention, due to an ever-increasing improvement in the details of the product.

We can never hope to depend upon the field service-stations to provide detailed records such as copies of every work-order covering the work they do. This involves entirely too heavy a clerical expenditure both in the field and at the home office. Furthermore, it is very questionable whether that would be desirable except in individual instances like the placing of a new model or an entirely new design in the field. Then the detail should be carried on for a limited period only.

The service-station should keep a running record of the exact nature of every job. This can be expressed in terms of billing or simply in a qualitative measure indicating what work was done regardless of the time or cost involved. From the service manager's standpoint, it seems that the qualitative analysis is more desirable because it is simple and provides the maximum amount of information for the least effort.

The gradual expansion of the flat-rate system automatically cares for the cost and the time analysis. What the engineer is particularly interested in is whether difficulty is experienced and how frequently with any particular component of his automobile. If valve trouble is encountered, it is his job to determine whether the quality of the material, the method of installation or any shortcoming of the design is the real cause of the trouble. It is not the function of the service-manager's record to indicate this.

The engineering department is usually well versed in its competitors' designs. On one car the grinding of valves takes a few hours. With another car of a similar class it may require a day. The flat-rate system soon points out very plainly such shortcomings. In this instance the comparison counts for or against only when both cars require the grinding at about the same frequency. It is this sort of information that the service department must be in a position to furnish, not guessing at it from personal local experiences, but obtaining it from data from the numerous points scattered throughout the Country.

One of the activities of the General Motors Research Corporation is to carry on extensive car-tests. We are interested primarily in ascertaining the good points and the shortcomings of different cars under operating conditions that are comparative. We obtain cars, usually through regular commercial channels to assure that we get the regular production product built by General Motors subsidiaries or by competitors or other cars that may have interest as indicating new development. These cars are run over roads that represent typical all-round conditions of city and country driving. So far as possible they are operated 24 hr. per day. They are inspected and adjusted periodically and, if necessary, are given such overhauling as will keep them in satisfactory operating condition. Tests are conducted on the basis of 25,000 or 50,000 miles of service and a detailed record is kept of just what happens, just what is done and what is found from day to day.

Charting the Information

We have used many methods of arranging the information thus obtained so that it can be analyzed readily to reveal the advantages and shortcomings of design as

shown in service. To make this readily available to the engineer, we find a chart system permitting comparison of the details of different cars a most constructive and useful record. It is this comparative record that every service department should teach the service-stations to keep. It should provide information of what is going on and, incidentally, make it available through weekly returns to the service manager for many constructive purposes.

Through the process of elimination, we have found that all references pertaining to the parts and the functioning of a car can be included under about 125 headings. These headings, you will note by reference to Fig. 1, are broken-up into major classifications, dividing a car into the following components: engine, electrical, clutch and transmission, running-gear, chassis and body. These major classifications are subdivided into the more detailed components so that, regardless of what trouble is experienced, there is a place on the chart in which to indicate by a dot what trouble was experienced with a particular functioning of the car.

The typical chart gives the analysis of troubles experienced on our road tests with cars selling at from $300 to $3,000. The dots indicate in each instance that trouble was experienced with the item concerned. No effort is made to show whether the trouble was serious or costly to repair; that is, the chart does not indicate the nature of the trouble any more than the red signal advises the railroad engineer of what is happening in the block ahead; but it does give warning that there is need of attention and investigation. The location of a dot indicates the mileage after which the trouble occurred. In our analyses at the laboratory we are interested in comparing a car with other cars of the same or a different price-class. The density of dots under given headings automatically brings out the information desired. In this particular chart, we are comparing cars that vary in price classifications ten-fold. The real picture it brings out is of interest. From a customer's standpoint, a broken gasoline-line, or a burnt-out head-lamp bulb, while not a major defect, causes inconvenience and delay.

The interesting thing brought out by the chart is that the troubles we expect in motor cars and the improvements the engineer contemplates making do not always conform with the items that are causing the customer the most trouble. The industry has not reached a point where cars can run 25,000 or 50,000 miles without some adjustments and some maintenance; thus, all cars are legitimately subject to adjustments and repairs.

In the early days of the industry, the engine was the source of much difficulty in the field. This chart, Fig. 1, giving a cross-section of the products of the industry, shows that the powerplant of regular commercial products is comparatively free from repeated troubles. This is not true in the case of items that are considered "incidentals" by the engineer and by production men, such as wiring, fuel and oil lines, head-lamp connections and bulbs, cooling systems, brakes and sheet-metal work. These all demand considerably more attention than one would think necessary.

The thought involved in presenting this type of analysis to the service-men is that the engineer must receive from the field information of the kind indicated, and that the service-man must be in a position to furnish it. We do not feel that anything would be gained by making a specific analysis of repair-costs in a record of this sort. We are interested only in indicating the satisfaction to the customer of one car as compared with another. By keeping this point clearly in mind, we eliminate all the confusion of classifying the troubles that would otherwise enter into a record. The fact that one car has excessive trouble is in itself sufficiently serious to warrant a specific detailed investigation of the component involved.

The number of engineering-department investigations that might be warranted immediately narrows down to an easy determination of the most serious troubles to be investigated first. The value of this kind of record is that it points out shortcomings in one's products that are often overlooked simply because they are believed to be of such minor importance that no investigation is necessary. This becomes obvious from a study of the location of the dots on this chart.

Cooperation Between Factory and Service-Men

All companies are developing some coordination between the factory and the repair-stations that represent their product in different parts of the Country. The development and growth of the flat-rate system brings with it much interesting analysis that the customer will make relative to the cost of maintenance of cars in which he is particularly interested. It is felt that with very little education on the part of the service department, the various repair-stations and the people who represent them can make this information available to the engineering department at all times with very little effort or delay.

From analysis, it is evident that the dealers who represent successful motor-car producers are making money. There are ups and downs, but generally those companies are represented by dealers who are successful business men. If we go back of this we will find the main reason to be that the manufacturer has helped his representative to handle his business and sell cars in a business-like manner.

The service manager must take the same interest in those who represent his department in the field by helping them to conduct the business economically and efficiently. It is felt that every service garage must be keenly interested in knowing just what work has been done other than that indicated by the cash-register. Information as to the frequency of valve-grinding, the adjustment of steering-gears and clutches and many other operations not now recorded, is of interest to any business man who realizes that the ratio of income to expenditure is governed entirely by these items and by the manner in which one is organized to care for them. Such information obtained under a given local condition permits one to analyze how desirable special equipment may be to handle certain types of service-operation. It is of interest in connection with the number of men on the payroll and the type of men required. In fact, it is the indicator of what variable work the particular business is doing. Very few service-stations today can furnish this information, although the total effort involved in doing so is practically negligible.

Some of the General Motors subsidiaries, believing that the success of business is based on an intimate knowledge of what one is called on to do, are beginning to keep a record of this nature. This constitutes a barometer of the events in each locality. A record of this sort made cumulative over several years indicates very clearly the types and frequency of work and the comparison between different models at different seasons of the year in any particular locality.

It is felt that a chart of the kind shown, on a small scale designed to cover a specific production, can be provided profitably by each of the companies, so that every authorized service-station can from day to day place a dot for each of the items against particular models to

show the work done. In return for the help given by the service manager, the service-station should give him a carbon copy of the chart weekly. Thus, the charts can be made available from all sections of the Country and consolidated into a single chart forming a valuable record for the service department. It calls the attention of the respective organizations to the seriousness of current troubles or to the freedom from a trouble that was once serious. It also permits an immediate check on what is happening in all sections of the Country relative to a particular detail, and allows one to determine what investigation is necessary to correct or eliminate the difficulty.

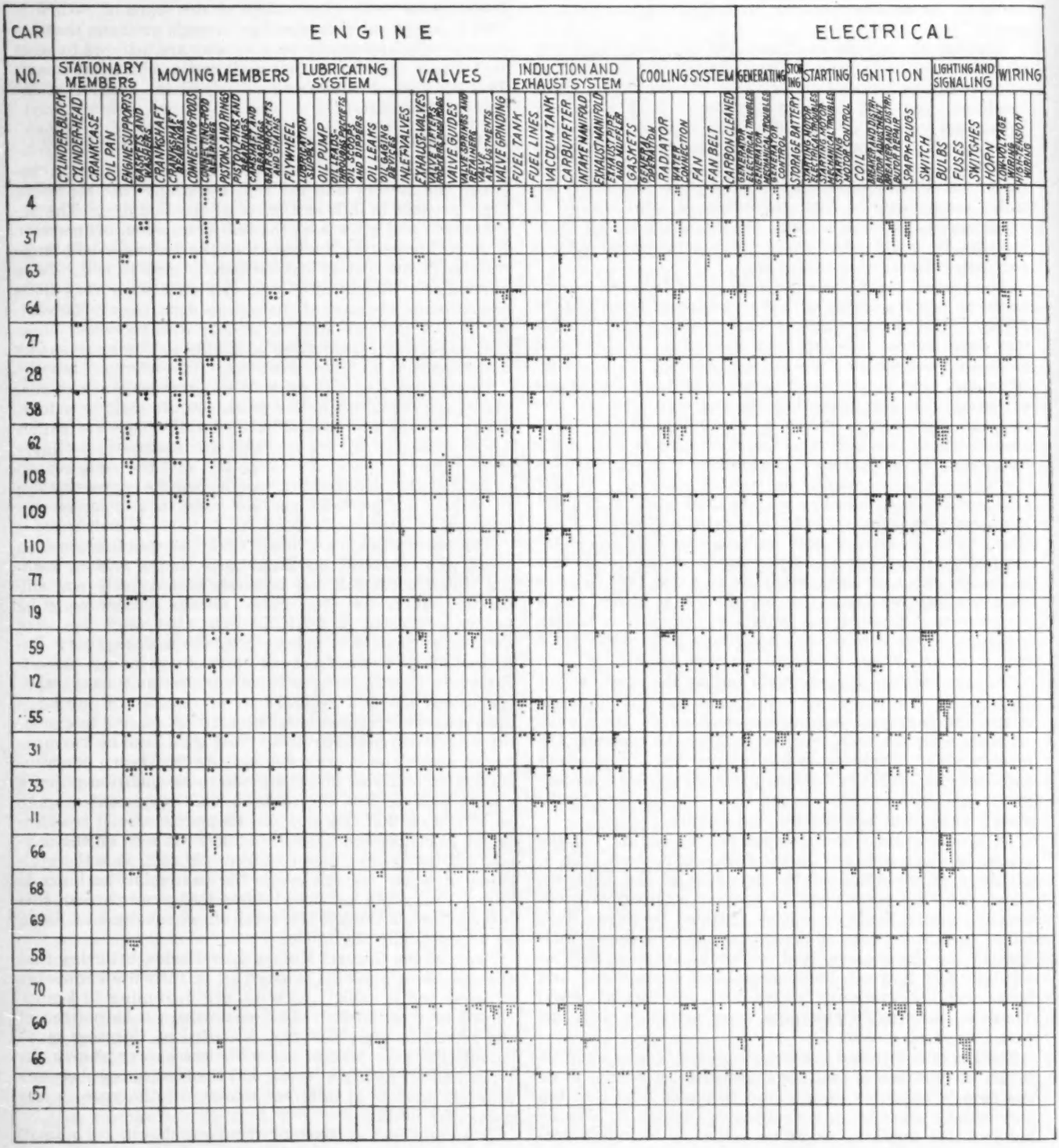
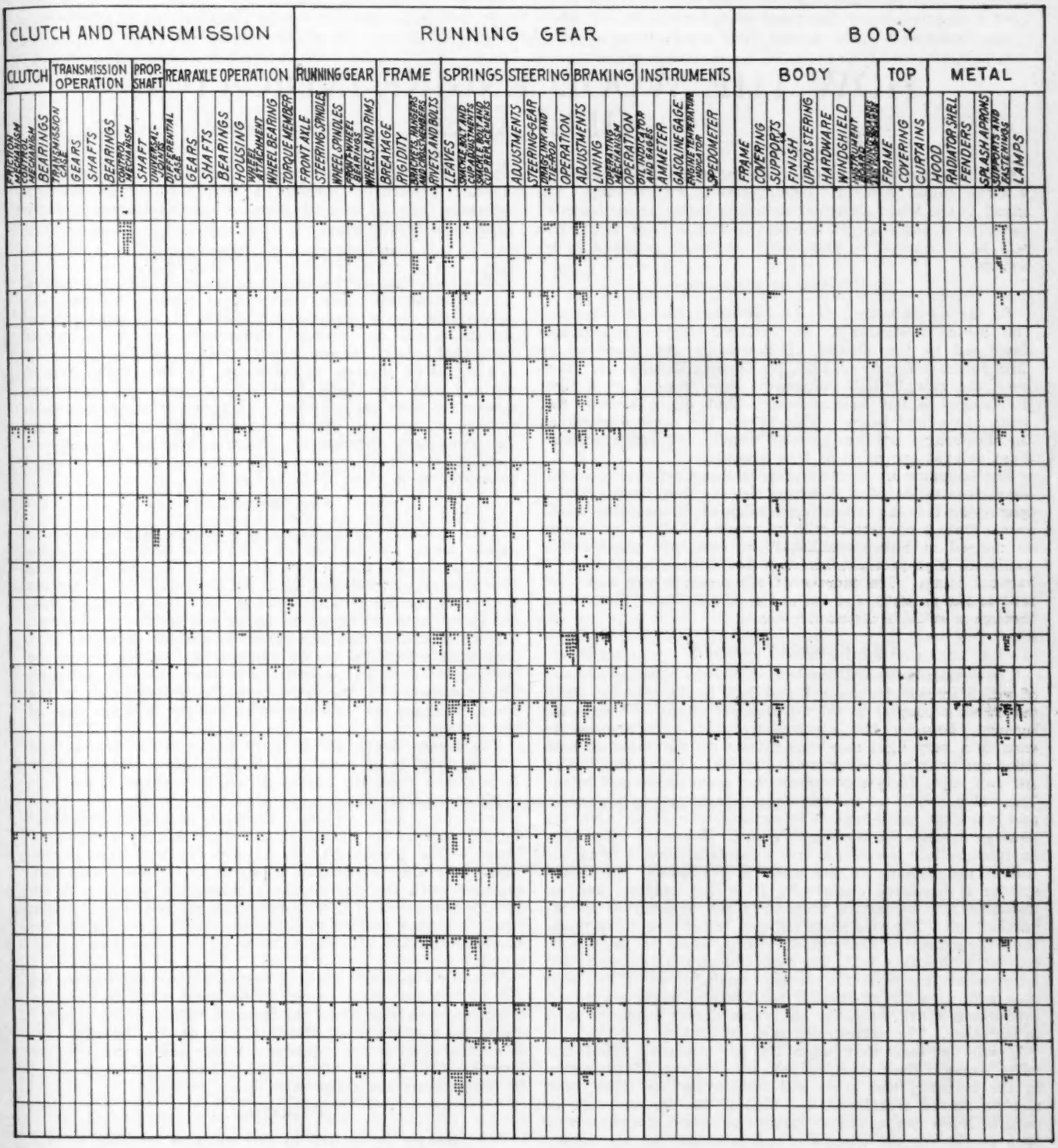


FIG. 1—HOW THE GENERAL MOTORS RESEARCH CORPORA On the Original of This Chart, Which Is 15 Ft. Long, Are Recorded by the Subsidiaries of the General Motors Corporation or Their New Developments. The Chart Is Divided into Five Major Groups in Turn Are Subdivided and Still Further Subdivided into a Total Column Is Theoretically Divided in Five Columns, Each of Which Column Indicates the Period of the Test in Which That Particular

The advantage of plotting a record of this sort with dots, in place of actual figures, is that in analyzing the seriousness of trouble in operation one does not have to carry numerous totals mentally. At the laboratory our current master-chart is over 15 ft. long and occupies an entire wall of an office. To distinguish closed from open cars on the master chart, different colors or different shapes of dot or a combination of the two can be used. In the event that a dot for a single trouble involves congestion on the chart, a dot may represent five troubles,

(*Concluded on p. 73*)



TION RECORDS EXPERIENCED WITH ITS TEST CARS

the Faults That Develop in the Regular Road Tests of Cars Built Competitors or Other Cars That Are of Interest as Indicative of Representing the Principal Components of the Car and These Groups of 121 Headings Covering the Troubles Encountered. Each Vertical Represents 5000 Miles of Travel, and the Position of the Dots in the Trouble Showed Up.

Research Topics and Suggestions

THE Research Department plans to present under this heading each month a topic that is pertinent to the general field of automotive research, and is either of special interest to some group of the Society membership or related to some particularly urgent problem of the industry. Since the object of the department is to act as a clearing-house for research information, we shall be pleased to receive the comments of members regarding the topics so presented, and their suggestions as to what might be of interest in this connection.

HOW THE WOOD ENGINE-INDICATOR OPERATES

AN instrument of ingenious design at the headquarters of the Royal Aircraft Establishment, Farnborough, England, is the Wood electrical recording indicator for internal-combustion engines. It is believed that a brief description will be of interest to automotive engineers engaged in research.

Principles of Operation

So far as its basic principles of operation are concerned, this device is similar to the balanced-diaphragm indicator developed at the Bureau of Standards and described in THE JOURNAL for April, 1920, by Thomas Midgley, Jr. However, the new British instrument uses, instead of a light diaphragm, a flat balanced-valve that closes against flat seats above and below. This serves the same purpose as the diaphragm but has greater weight and perhaps somewhat delayed operation on that account.

The indicator as a whole may be described briefly as follows: It consists of a pressure element that screws into a spark-plug hole, an indicating mechanism, a recording mechanism that is connected with an engine shaft so as to run as desired at either crankshaft or camshaft speed and a source of high-pressure air, together with a hand-operated vacuum pump. The sources of air pressure are connected both to the pressure element and to the indicator mechanism through a suitable distributor box.

The Pressure Element

The pressure element consists of a brass housing, one end of which screws into a spark-plug hole in the cylinder, while the other is coupled to the air-pressure supply. Within the housing, between the air-pressure and cylinder-pressure ends, is a very light steel disc-valve with flat faces on both sides and with a guide spindle attached. Corresponding to the two valve faces are narrow flat seats above and below. The valve-spindle is entirely free to move along the guide and when the valve-head is in contact with either seat, the passage through the housing is closed. When the valve is in an intermediate position, a free passage around it from one end of the housing to the other is available. The valve-spindle is insulated electrically from the housing, and an insulated lead is carried from it to the primary of an induction coil. The two seats between which the valve floats form the ground of this circuit. Thus, when the valve is in contact with either seat, the electrical circuit is closed; for intermediate positions the circuit remains open. The valve then acts as a circuit-breaker for the coil whose secondary produces a spark whenever the valve passes from one seat to the other. The valve-travel is about 0.03 in.

It will be seen that when the air pressure above the valve exceeds that produced at any instant of the cycle in the cylinder, the valve will remain on the lower seat and no record will be made. But if the air pressure is reduced below the maximum cylinder-pressure, the valve will open at the instant when the two pressures become equal, and for any lower pressure above the valve, the latter will leave the lower seat and rise to the upper seat whenever the cylinder pressure reaches this value. When the cylinder pressure again falls, the valve will return from the upper to the lower seat, producing a spark in the recording mechanism on each occasion. Pressures above the valve are applied arbitrarily through a distributor from an air-pressure tank or vacuum pump connected to the indicator head by a flexible pipe.

The Indicator Mechanism

The recording mechanism is designed to plot a curve of pressures against time rather than against volume. To accomplish this a spring-loaded piston of the same general design as the conventional steam-engine indicator but of somewhat larger size and longer stroke is used.

The piston motion is controlled by two main tension springs and two light back-to-back compression springs concentric with the cylinder. All four springs are used in making a complete diagram; for a light-spring diagram the two main springs are disconnected, which makes it possible to record suction pressures as well as positive pressures up to about 20 lb. per sq. in.

The Recorder

This indicator mechanism moves a recording spark-point axially along the surface of a drum rotating on a horizontal axis. Parallel motion of the spark-point relative to this axis is accomplished by a parallel multiplying linkage that connects the indicator piston with the recording link, the latter terminating at its upper end in the spark-point. The lower end of this link moves in a guide connected to a high-tension terminal of the induction coil which brings the spark-point to high potential whenever the coil operates. The movement of the spark-point is proportional to the pressure above the indicator valve and is 7.8 times that of the piston.

The record drum, which is 12 in. in circumference and 9½ in. long, is of metal and is mounted on ball-bearings. It is driven from the engine at either crankshaft or camshaft speed through a special clutch and by any convenient connection, usually a chain. Backlash is largely eliminated by fitting an idler pulley to the chain and by applying a brake to the drum-shaft. The clutch device is arranged so that the drum can first be brought up to speed and then engaged with the driving-shaft through a positive clutch having but one dog; this feature assures that the recording drum is always started in phase with the engine. Thus the dead-center mark will always come at the same place on the drum.

The drum carries a piece of special carbon paper intended for use with a spark record. The spark-point moves at a relatively slow rate along the drum in light contact with the paper, its position being determined by the air pressure that is applied alike to the indicator cylinder and to the pressure element; thus the position of the point always corresponds to the pressure above the valve disc.

Operation

Air pressure is applied to the indicator cylinder and to the balanced valve. At a given instant when this pressure has reached a certain value and the spark-point is in a corresponding position on the chart, the compression pressure becomes equal to that of the air and the valve is driven off its seat. This causes a spark to puncture the record chart. The

cylinder pressure continues to rise and then decreases until it is again equalized by the air pressure when the valve is driven back and another spark occurs. During the interval between sparks the drum has turned by an amount that corresponds to the change in engine-piston position; so the second puncture comes at a different point on the chart. One point is thus obtained on the compression and the expansion stroke for each revolution of the drum. In this way, with the air pressures varied over the desired range, the complete indicator diagram is traced. It will be understood that the completed diagram will include points representing a number of successive cycles of engine operation.

The time necessary to take a record is usually from 10 to 40 sec., depending upon the engine speed and the type of card that is produced. The records taken in this way can be used photographically as negatives for making blueprints.

In one design of recording drum a supply of fresh record-paper and the used part of the paper are held on rolls within the drum in such a way that it is only necessary to turn a knob to renew the record-paper. This is designed especially for taking records from aircraft engines in flight.

STANDARDIZATION

H. G. BURFORD, in his presidential address to the Institution of Automobile Engineers, pointed out that standardization in the automobile field, so far as the design of parts is concerned, is intended to apply only to the detail fittings that are common to all cars, neither individuality nor originality being hampered or interfered with. He outlined the advantages of standardization as they are reflected in the drafting-room and in the shop. In connection with the latter, he said that the manufacturers should be under no obligation to maintain dies, jigs and patterns to meet what in 9 cases out of 10 is simply the individual fancy of the designer. He deplored the making of the head of a bolt, for example, 1/32 in. thicker than the standard when there is no definite good reason for this. The greater the number of car details that are standardized, the more easily, quickly and cheaply the user will be able to get renewals. In reiterating his opinion that standardization involves no sacrifice of reputation for high-class work, he gave the following summary of advantages of standardization:

Manufacturing

(1) Number of sizes of sections, dies, jigs, patterns, bolts, nuts, etc., reduced to the minimum

(2) Production of parts reduced in cost because (*a*) a given tool equipment when set-up will be utilized for a longer period on greater quantity production, (*b*) there will be a reduction in tool and jig costs and (*c*) there will be a reduction in overhead per piece

(3) Increased saving by producing in quantities, the producer having more confidence in a standard line

Selling

(1) Sales would be easier and export business more readily effected

Operating

(1) Repairs more easily effected and replacements more quickly obtained so that in case of breakdown a vehicle is out of service for a shorter period

(2) Varieties and quantities of spares considerably reduced

He advised strongly that every manufacturer make a careful and thorough study of the whole question of the advantages to be derived from standardization. This is very good doctrine, for, as mentioned by Mr. Burford, all of the work and energy expended in the preparation of a standard is practically wasted if only a few firms adopt the standard. The first step is for every firm to express its approval of the principle and then to nominate one or more members of its technical staff, whose specific duty it shall be to deal with all questions of standardization, to suggest points for standardization, to attend committee meetings, to criticize suggested standards and, finally, when a standard is approved to see that everyone who is in any way concerned is made acquainted with that standard and that it is adopted.

LAWRENCE B. SPERRY

ACCORDING to press dispatches from London, Lawrence B. Sperry, son of Elmer A. Sperry, president of the Sperry Gyroscope Co., Brooklyn, N. Y., was drowned in the English Channel Dec. 13, 1923, while flying to Amsterdam. His wrecked airplane was recovered 3 miles from Rye by coast guards, but no trace of its pilot was found. Mr. Sperry left Croydon, the London air-terminus, that morning. He was seen to fly out to sea by workmen on the shore; shortly afterward they saw the airplane crumple and fall into the water. It appeared suddenly to collapse, but no flames were noticed. A lifeboat was sent out, but the aviator could not be found. The airplane was a small one.

Mr. Sperry was born Dec. 21, 1893, at Chicago. He attended public school in New York City, being graduated from the Erasmus Hall High School in Brooklyn. He was credited with being the first to join Naval Flying Corps No. 5 in 1917, and with having invented the Sperry stabilizer, having previously been in charge of the airplane department of the Sperry Gyroscope Co.

His brilliant career is indicated best by brief mention of the reports of some of his achievements. In 1914 he won a $10,000 prize in an airplane contest in France. Through use of the Sperry gyroscope, invented by his father, he startled spectators by riding in his airplane without touching the controls, while his mechanic walked out on one of the wings. When Mr. Sperry returned to America, he gave exhibition flights over New York City. He was the first to install and use succesfully a radio set in an airplane. Subsequently, in 1917, he was the first to loop-the-loop in a hydroplane. In that year also he was awarded the Collier trophy by the Aero Club of America, a trophy awarded annually for the greatest achievement in aviation in America. Recently he demonstrated that an airplane can be equipped with skids in place of wheels for landing, thus making short landing-stops possible. He also introduced the sport of ski-planing over snow and ice.

Mr. Sperry was elected to Junior Member grade in the Society Sept. 12, 1916.

Balance of the Cadillac V-63 Engine

By E. W. SEAHOLM[1]

Illustrated with DIAGRAMS AND PHOTOGRAPH

THEORETICALLY, the idea of constructing a 90-deg. V-type-engine crankshaft with crank-throws in two normal planes, instead of in one plane as is customary, is not new; in fact, it has been discussed in textbooks and in the technical press from time to time. Articles on the subject dwell on the advantages of such an arrangement, pointing out that it results in the elimination of secondary forces as vibration factors. However, the articles leave unsolved the removal of the couples caused by the disposition of the crank-throws. It can be conceived readily that, with these forces present, complete smoothness cannot be realized.

In its study of engine fundamentals, the General Motors Research Laboratories, Dayton, Ohio, has investigated the possibility of counteracting couples connected with this type of shaft and has arrived at a solution through the employment of compensating weights properly proportioned and disposed along the crankshaft. This method of balancing has its first application in the V-type eight-cylinder engine now built by the Cadillac Motor Car Co.

Some of the theory of secondary forces must be included to convey a clear picture of the factors involved in this system. It is not being covered with the thought of contributing anything new to the excellent literature existing, but rather to present it in an elementary manner for the sake of completeness.

RECIPROCATING FORCES

Reciprocating forces in an engine are the variable forces required to accelerate and retard a piston and a portion of its connecting-rod alternately during a crank revolution. These forces act along the axis of the corresponding cylinder, react upon the main bearings of the crankshaft, alternate in direction and vary approximately in intensity according to the following expression:

$$[Wv^2/gL_c]\ [\cos\omega \pm (L_c/L_r)\cos 2\omega]$$

where

g = the force of gravity, 32.2 approximately
L_c = the length of the crank in feet
L_r = the length of the connecting-rod in feet
ω = the angle of the crank with the axis of piston travel in degrees
v = the velocity of the crankpin in feet per second
W = the weight of the reciprocating parts in pounds

Since Wv^2/gL_c is assumed to be a constant factor during a crank revolution for any given number of revolutions per minute, the value of the variable factor only, $[\cos\omega \pm (L_c/L_r)\cos 2\omega]$, is expressed decimally in Figs. 1, 2 and 3. The lines represent to scale both the relative value of the variable decimally expressed factor and the actual force represented by the expression already given.

The left half of Fig. 1 shows the direction and the relative intensity of the reciprocating forces for any piston and its connecting-rod in the right-hand block of the Cadillac engine for each 15 deg. The force for any crank position shown reacts upon the crankshaft bearings, *a*, in the axis of the piston travel; but, for convenience, it is shown in relative intensity and direction by the line and arrow at the crankpin. For the position of the piston and the connecting-rod shown, the series of lines represents the direction and intensity of the reacting force, in the axis of the piston travel upon the crankshaft bearings, that tends to produce vibration. It will be noted that, while always acting in the axis of the piston travel, the forces differ in intensity for various positions of the crankpin. The right half of Fig. 1 gives

[1] M.S.A.E.—Chief engineer, Cadillac Motor Car Co., Detroit.

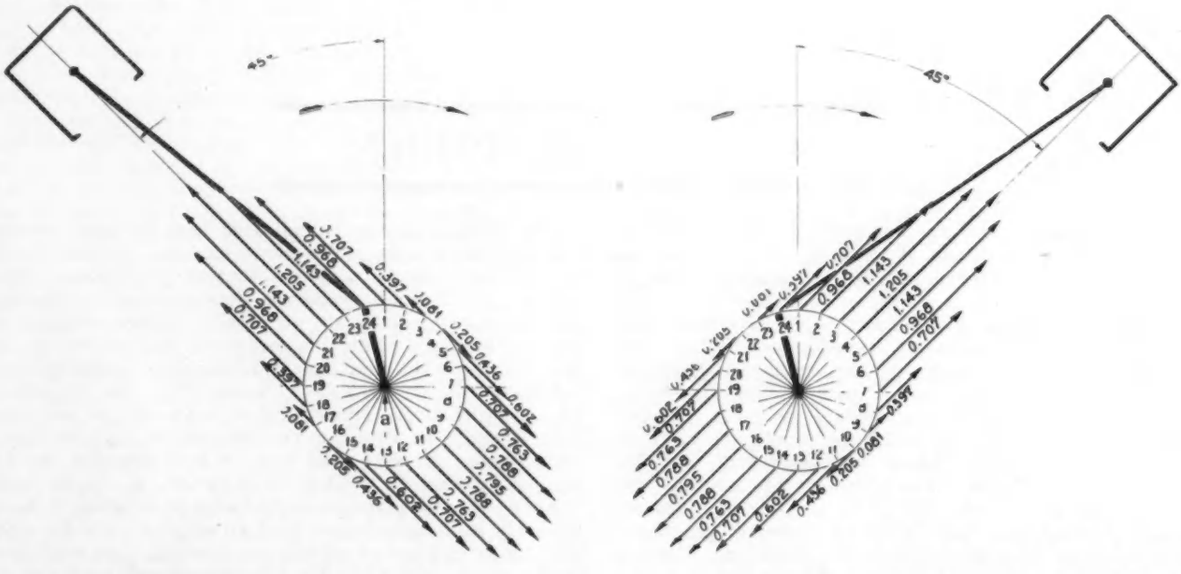


FIG. 1—DIAGRAMS SHOWING THE DIRECTION AND THE RELATIVE INTENSITY OF THE RECIPROCATING FORCES FOR ANY PISTON AND ITS CONNECTING-ROD IN A CADILLAC ENGINE
The Diagram at the Left Gives the Information for a Cylinder in the Right-Hand Block for Each 15 Deg. of Crank Travel, while the Same Information for a Cylinder in the Left-Hand Block Is Presented at the Right

the corresponding information for any piston and its connecting-rod in the left-hand block.

Fig. 2 shows in heavy lines the resulting forces formed by combining the separate forces produced simultaneously by the right and left-hand pistons and the rods connected to any one crank. Thus, at the crankpin position No. 24 the direction and the magnitude of the two forces as given for crank position No. 24 in Fig. 1 are shown in faint lines. The force for the right-hand rod and piston is 0.968 (Wv^2/gL_c). The force for the left-hand block is 0.397 (Wv^2/gL_c). The resultant of these two forces is 1.046 (Wv^2/gL_c), as in Fig. 2. It will be noted that, with the exception of the horizontal and the vertical crank-positions, none of the resultant forces is in a radial line.

Fig. 3 is developed by resolving each of the resultant forces in Fig. 2 into radial and horizontal-component forces. It will be noted that the radial component of the

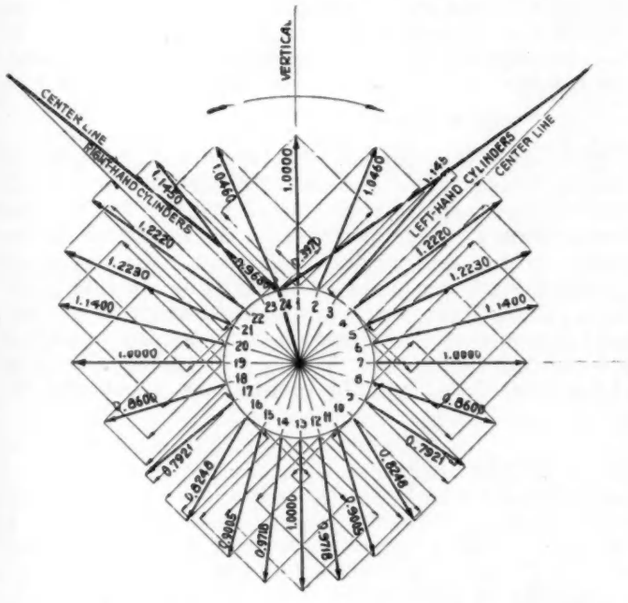


FIG. 2—RESULTANT OF THE COMPONENT FACTORS OF A PAIR OF CONNECTING-RODS AND PISTONS

The Resultant Forces, Which Are Shown in Heavy Lines, Were Obtained by Combining the Separate Forces Produced Simultaneously by the Right and Left-Hand Pistons and the Rods Connected to Any One Crank, as Shown in Fig. 1. The Direction and the Magnitude of These Forces Are Represented by the Light Lines

reciprocating force remains constant in intensity for every position of crank during a complete revolution and that only the horizontal component varies in intensity and direction.

Fig. 4 shows the angular relation of the four cranks of the Cadillac V-63-engine crankshaft, with crank No. 1 15 deg. to the left of a vertical plane, and corresponding to crank position No. 24 in Fig. 3. Crank No. 4 is 180 deg. from crank No. 1, corresponding to crank position No. 12 in Fig. 3. Crank No. 2 is 90 deg. to the right and crank No. 3 is 90 deg. to the left of crank No. 1, corresponding to crank positions Nos. 6 and 18, respectively, in Fig. 3.

In Fig. 3 it will be seen upon inspection that the radial component of the reciprocating force corresponding to crank No. 4, position No. 12, is in the same plane but acts in the opposite direction from that of the corresponding force for crank No. 1, position No. 24, and that it is separated from the latter force by the axial distance between the mid-positions of crankpins Nos. 1 and 4 as

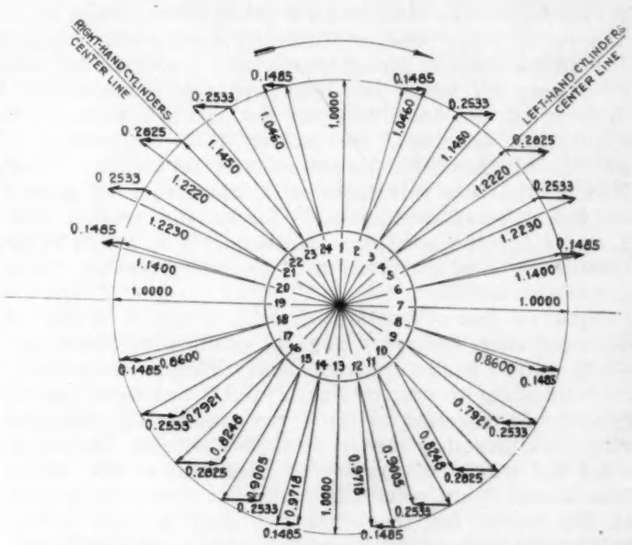


FIG. 3—THE RESULTANTS FOR THE VARIOUS CRANK POSITIONS SHOWN IN FIG. 2 HAVE BEEN RESOLVED INTO THEIR RADIAL AND HORIZONTAL COMPONENTS

It Will Be Noticed That the Radial Component of the Reciprocating Force Remains Constant in Intensity for Every Crank Position during a Complete Revolution and That Only the Horizontal Component Varies in Direction and Intensity

shown in Fig. 4. It will be seen also that the horizontal-component forces corresponding to these same two cranks are identical in intensity and direction, and that they are separated by the same axial distance as the radial-component forces.

Similarly, for cranks Nos. 2 and 3, corresponding respectively to positions Nos. 6 and 18 in Fig. 3, the radial forces are equal in intensity and opposite in direction, the horizontal-component forces are identical in intensity and direction, and each of these two pairs of forces is separated axially along the shaft by the distance between the mid-positions of cranks Nos. 2 and 3.

It will be noted further that the horizontal-component

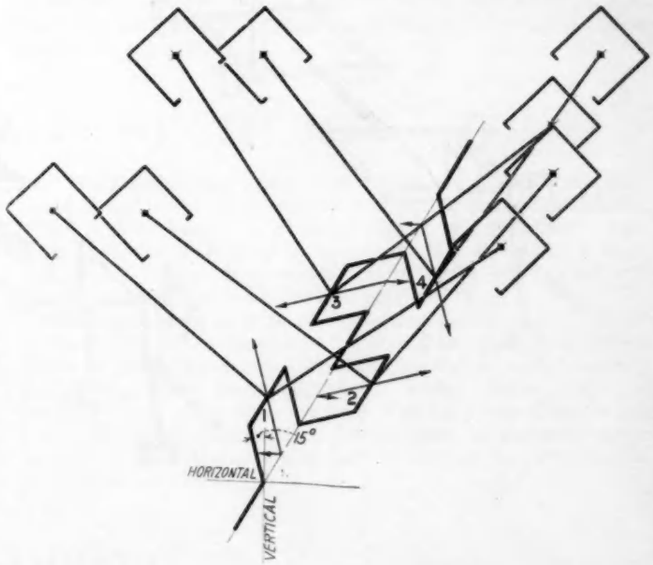


FIG. 4—THE ANGULAR RELATION OF THE FOUR CRANKS OF A CADILLAC V-63 ENGINE

In This Diagram Crank No. 1 Is 15 Deg. to the Left of a Vertical Plane, Cranks Nos. 2 and 3 Are 90 Deg. to the Right and the Left Respectively of Crank No. 1, and Crank No. 4 Is 180 Deg. from Crank No. 1. These Positions Correspond to Nos. 24, 6, 18 and 12 Respectively in Fig. 3

forces for cranks Nos. 2 and 3 act in the opposite direction to the corresponding forces for cranks Nos. 1 and 4 and all are equal in intensity. Recalling that the horizontal-component forces are misplaced for convenience of description and that they act through the axis of the crankshaft bearings, and noting that the center of gravity of the horizontal-component forces for cranks Nos. 2 and 3 is coincident with the center of gravity of the horizontal-component forces for cranks Nos. 1 and 4 for the positions mentioned, it is evident that these horizontal components of the reciprocating forces are in equilibrium.

Upon further inspection of Figs. 3 and 4, it will be observed that, for every angular position of the crankshaft, the horizontal-component reciprocating-forces corresponding to cranks Nos. 2 and 3 are equal to and opposite in direction to the corresponding forces occurring simultaneously for the other two cranks. Therefore, since the center of gravity of these forces for cranks Nos. 2 and 3 are coincident with the center of gravity of the forces for the other two cranks, they always balance in every angular position of the crankshaft and, therefore, can have no influence in producing vibration. However, the radial components of each of the reciprocating forces for cranks Nos. 1 and 4, always acting in the direction of their respective cranks, produce a couple in the plane of these cranks. Likewise, a couple is produced in the plane of cranks Nos. 2 and 3. These couples, each tending to impart a wabbling action to the crank, combine to produce vibration in the engine. The individual forces of these couples being radial, constant in magnitude and in synchronism with the cranks, can be counteracted by the addition of weights located diametrically opposite. To facilitate practical construction, these weights can be divided and applied to the prolongation of the cheeks adjacent to the crankpins, as shown in the left-hand drawing of Fig. 5.

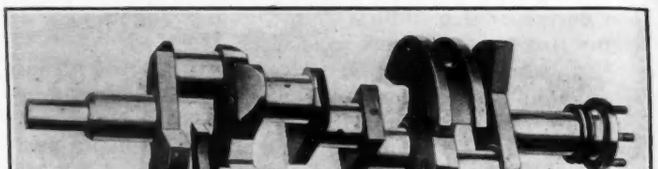


FIG. 6—A COMPLETED CRANKSHAFT
In Production Practical Dynamic Balancing of Each Counterweighted Shaft Is Secured by Adding to the Crankpins Concentric Weights of a Magnitude Calculated To Produce Forces Identical with Those Generated by the Piston and the Connecting-Rod Assemblies When the Engine Is Running

The centrifugal force produced by the lower end of a pair of rods, bushing, crankpin, cheeks and the like can also be balanced by providing weights in the prolongation of the adjacent cheeks, thus increasing each of the weights required for radial components of the reciprocating forces.

ARRANGEMENT OF COUNTERWEIGHTS

To facilitate production, the counterweights on the Cadillac crankshaft are arranged differently, to a slight degree, than is shown at the left of Fig. 5. The weights *a* that form a couple are replaced by weights *b* shown dotted in the central drawing, which form an equal couple, these being added to the existing weights, *a*, at these points. To produce a symmetrical weight symmetrically arranged on the intermediate cheeks, the weights *b* are added to the existing weights *a* by reducing the size of the pair of end weights, properly, as is indicated by

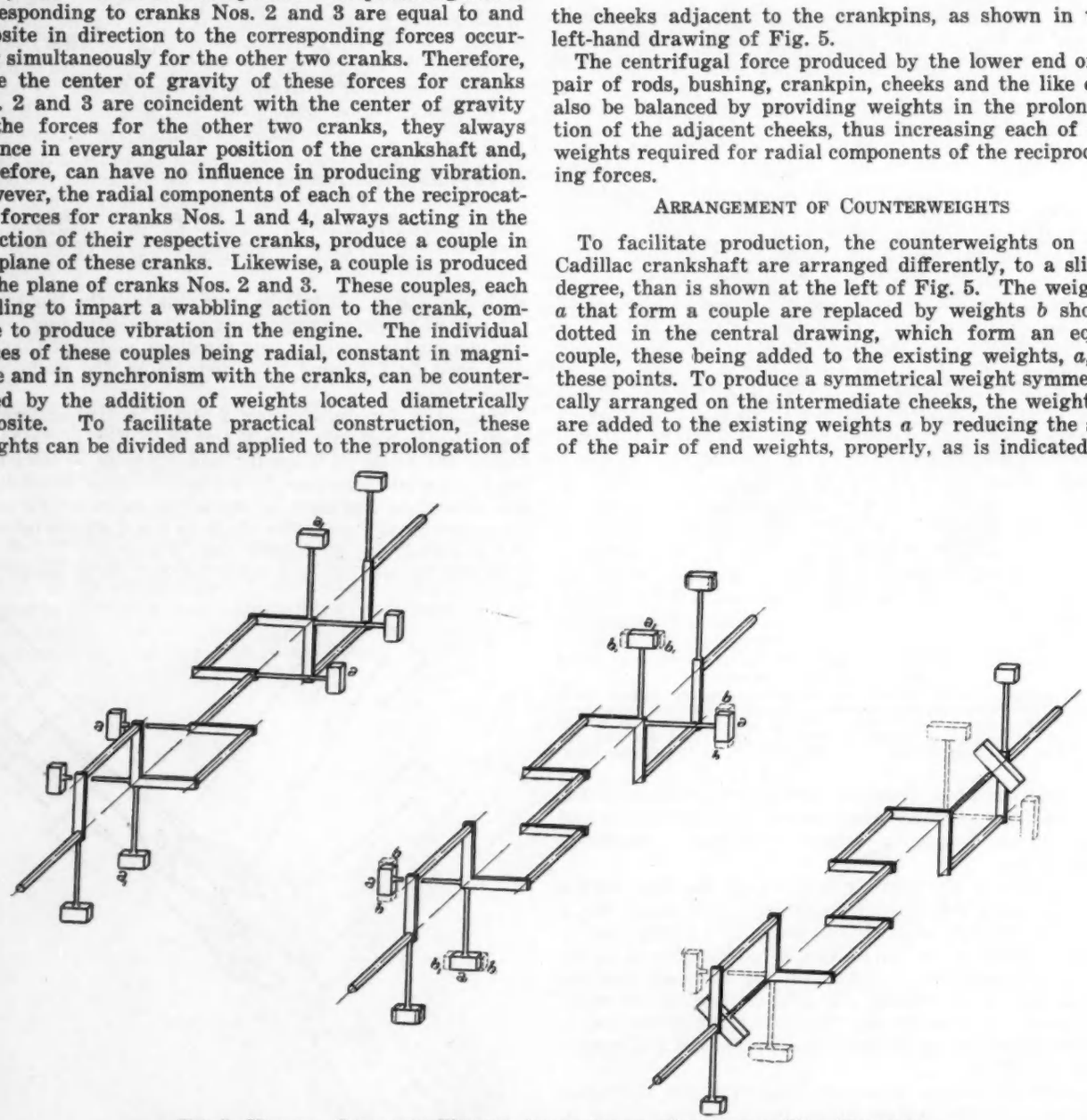


FIG. 5—HOW THE BALANCING WEIGHTS APPLIED TO THE CRANKSHAFT WERE DEVELOPED
At the Left the Weights Are Shown Divided and Applied to the Prolongation of the Checks Adjacent to the Crankpins To Facilitate Practical Construction. In the Next Step the Weights *a* in the Central Drawing Are Replaced by the Weights *b* and To Produce a Symmetrical Weight Symmetrically Arranged on the Intermediate Checks the Weights b_1 Are Added to the Weights a_1 and the Size of the Pair of End Weights Is Reduced as Shown by the Dotted Lines. The Final Arrangement Is Shown Diagrammatically in the Drawing at the Right in Which the Two Weights on the Intermediate Checks, Which Are Represented by Dotted Lines, Are Replaced by the Resultant Weights Shown in Full Lines and the End-Check Weights Are Reduced

the dotted lines. Finally, the two weights on each of the intermediate cheeks, shown dotted in the drawing at the right, are replaced with resultant weights that are shown in full lines which, with the pair of reduced end-cheek weights, indicate diagrammatically the arrangement of counterweights used on the Cadillac crankshaft.

Dynamic Balance

Obviously, a shaft of this type per se is not in dynamic balance. In fact, its dynamic unbalance must be such as to oppose exactly the forces caused by the piston and the connecting-rod assemblies. In production, practical dynamic balance of each counterweighted shaft is secured by adding to the crankpins, as shown in Fig. 6, concentric weights of a magnitude calculated to produce forces identical with those generated by the piston and the connecting-rod assemblies when the engine is running, the crank assembly then being balanced in a dynamic balancing-machine.

From the description already given and from reference to Figs. 3 and 4, it will be seen that the resultant radial force produced by the reciprocating masses of a pair of piston and connecting-rod assemblies is equal to the force produced by the reciprocating masses of a pair of piston and connecting-rod assemblies is equal to the force produced by concentrating at the crankpin a weight equivalent to the reciprocating portion of a single piston and connecting-rod assembly. If to this weight we add the weight of that portion of a pair of pistons and connecting-rods which revolves about the crankshaft center, we will have the proper weight to be placed on each of the crankpins while dynamically balancing the crankshaft assembly.

The method used to proportion the weight of a connecting-rod between reciprocating and revolving masses is to support the connecting-rod horizontally at the axis of the holes at the two ends and determine the weight at these points. The weight of the upper portion of a connecting-rod, together with the weight of its piston assembly, is considered to be reciprocating weight. The weight of the lower ends of a pair of connecting-rods, including the crankpin bushing, is considered to be the revolving weight. The total of these two weights is the weight required to be concentrically disposed on each of the crankpins while dynamically balancing the crankshaft assembly.

PROVIDING THE ENGINEER WITH SERVICE DATA

(*Concluded from p.* 67)

the first trouble being represented by an open circle, the second trouble by one-fourth of the circle being blackened, and so on until five troubles blacken the entire circle, forming a dot. If desirable, colored tacks or glass-headed pins can be used for the same purpose. Ink dots are practically as convenient as tacks and make a permanent record. This is the arrangement recommended if the records are to be of the greatest service.

The value of this record is determined entirely by the cooperation one can get from the various service-stations; a problem to be worked out independently by each organization. Just how this is approached is governed by past experiences with representatives in the field. We believe that no difficulty would be experienced in the field if proper personal contact between the service department and the service garage were established by periodical visits of a representative who would help the latter in the conduct of its business.

In using a chart system of this nature, it is very desirable to confine oneself to a nomenclature that will permit comparisons between different makes of car. While none of us desires to provide his competitors with a list of the weaknesses of his own products, we are all interested in eliminating the weaknesses of our products. Moreover, the competitive cooperation that has been instrumental in making the automobile industry the third largest business of the Nation will also do much to eliminate the large number of dots we find under some of the headings, common to all cars, a condition for which there should be no excuse.

HUGGING "TRADE SECRETS"

WE all know the engineer who keeps the little that he knows bottled up so tightly that it shrinks for want of an occasional airing. He goes to the meetings of his society or association and picks up what he can from the sideline but never contributes any of his own ideas or knowledge.

He seems to feel that if the other fellow knows as much as he does, the other fellow will be as big an engineer as he is, and that he will suffer by comparison. It is a matter of relativity with him. He expects to keep ahead by keeping the other fellow back. Watch him dry up and go to seed.

The man who gives the best that there is in him to his associates in the association and elsewhere gets the most out of life and out of the association. He gets a new grip on things by telling them, gets the benefit of the knowledge that their discussion brings out, perhaps corrects some misconceptions. New ideas replace or amplify those that he has culled and he keeps on growing bigger and brighter. And when a leader is wanted or somebody is looking for a man who knows things, he is the object of everybody's good will and the outstanding man for the position.

The same thing is true of firms and corporations. Many of them have dried up and gone to seed hugging a withering bunch of trade secrets and inside information, which usually their competitors know all about; while others, with the broader view, have come up and written themselves to the front with real contributions to the good of engineering in general and to that of their class of service in particular.—F. R. Low in *Power*.

WASTE IN INDUSTRY

IT is certain that there are a great many articles of everyday use in which the manufacturer would indeed be glad to undertake some cooperation in standardization, from which the saving in national effort would be interpreted not into millions but into billions of dollars. This does not mean we stamp the individuality out of manufacture or invention or decoration. It means basic sizes for common and everyday things.—Herbert Hoover.

TENTATIVE STANDARDIZATION WORK

Criticism of all tentative reports should be sent to the Standards Committee in care of the Society

S. O. WHITE SUBMITS REVISED REPORT

Alternate Construction Permits Mounting of Side-Gears in Case or Spider

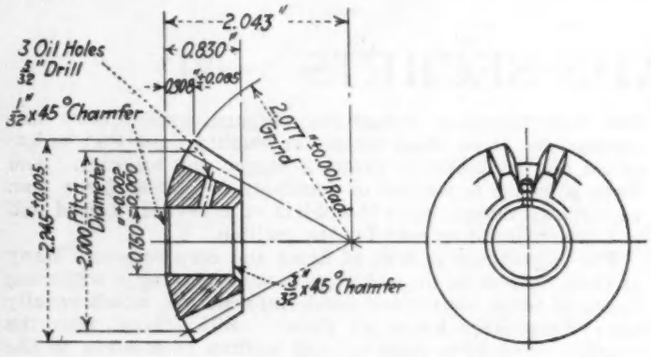
During the last 2 years the Subdivision on Differentials of the Axle and Wheels Division has been working on the standardization of four-pinion differentials. Its first report was published in the January, 1923, issue of THE JOURNAL on p. 124.

As a result of comments received by the Subdivision of which S. O. White of the Warner Gear Co. is chairman, the report was revised and certain dimensions, unnecessary to obtain interchangeability, eliminated; the complete report being extended to permit mounting the side-gears in the case as well as in the spider. The Subdivision report, revised as outlined, is given in the accompanying illustrations and tables. During the preparation of this report the Subdivision worked in collaboration with the differential gear committee of the American Gear Manufacturers Association, the personnel of these two committees being overlapping to some extent.

As the recommendation represents to a large extent a natural crystallization of practice, the existence of the designs in the S.A.E. HANDBOOK as recommended practice will greatly simplify the problems of the differential manufacturers who are now obliged to produce an immense number of designs differing only in unimportant details.

In order that the recommendation may meet the requirements of the best engineering practice, the Subdivision does not desire that the report be submitted to the Standards Committee at the January Meeting, but held over until the Summer Meeting so that the members of the Society will have ample time to analyze the report and submit suggestions as to revisions or additions that would make the proposed standard of more value to the industry. Comments and criticisms submitted to the Society will be referred to the members of the Subdivision.

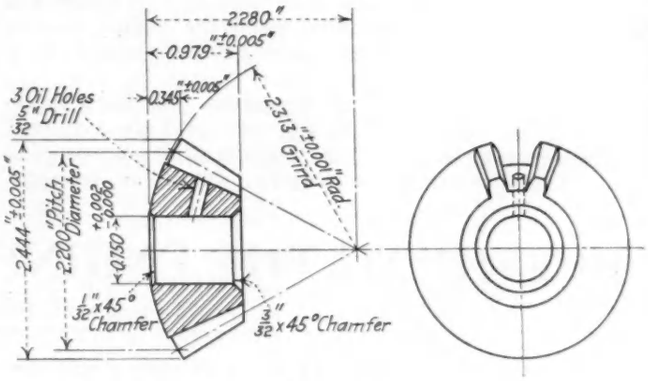
10-Tooth Pinion



PINION DATA	
Diametral Pitch	5-7
Pitch Angle, deg.-min.	29-3
Face Angle, deg.-min.	33-1
Chordal Thickness, in.[1]	0.3153
Corrected Pitch Depth, in.	0.1505
Addendum, in.	0.1429
Dedendum, in.	0.1785
Block Angle, deg.-min.	4-57
Pressure-angle, deg.	20

[1] Chordal thickness of 0.3153 in allows for 0.0060-in. backlash.

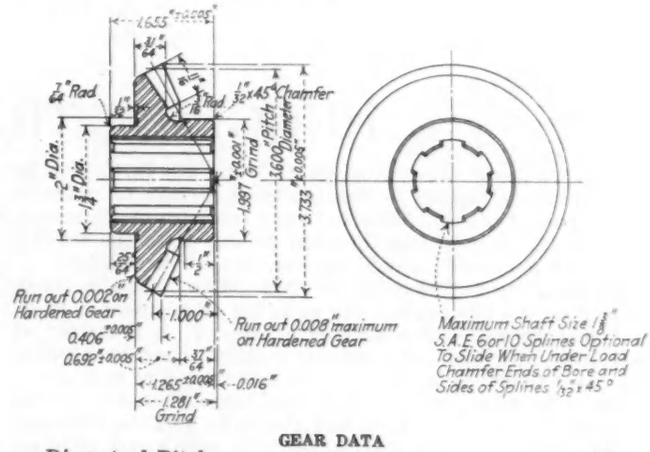
11-Tooth Pinion



PINION DATA	
Diametral Pitch,	5-7
Pitch Angle, deg.-min.	28-49
Face Angle, deg.-min.	32-24
Chordal Thickness, in.[2]	0.3130
Corrected Pitch Depth, in.	0.1530
Addendum, in.	0.1429
Dedendum, in.	0.1785
Block Angle, deg.-min.	4-22
Pressure Angle, deg.	20

[2] Chordal thickness of 0.313 in. allows for 0.006-in. backlash.

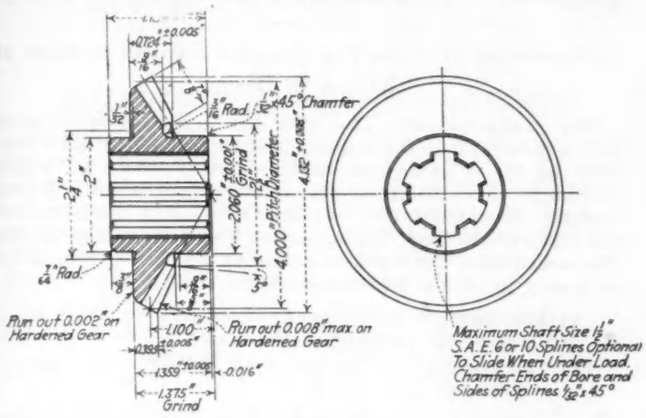
18-Tooth Side-Gear for Spider Mounting


1.655" ±0.005"
1/64" Rad.
1/16" Rad.
1/32" x 45° Chamfer
2" Dia.
1.397" ±0.001" Grind
1.600" Pitch Diameter ±0.005"
3.733"
1/2"
Run out 0.002" on Hardened Gear
1.000"
Run out 0.008" maximum on Hardened Gear
0.406" +0.005 -0.000
0.692" ±0.005"
1.265" ±0.005"
0.016"
1.281" Grind
Maximum Shaft Size 1 3/8" S.A.E. 6 or 10 Splines Optional To Slide When Under Load Chamfer Ends of Bore and Sides of Splines 1/32" x 45°

GEAR DATA	
Diametral Pitch	5-7
Pitch Angle, deg.-min.	60-57
Face Angle, deg.-min.	64-55
Chordal Thickness, in.[3]	0.3093
Corrected Pitch Depth, in.	0.1453
Addendum, in.	0.1429
Dedendum, in.	0.1785
Block Angle, deg.-min.	4-57
Pressure Angle, deg.	20

[3] Chordal thickness of 0.3093 in. allows for 0.0060-in. backlash.

20-Tooth Side-Gear for Spider Mounting

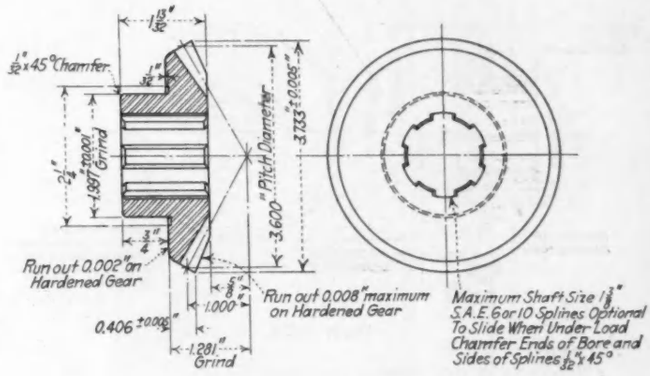

Run out 0.002" on Hardened Gear
Run out 0.008" max. on Hardened Gear
Maximum Shaft Size 1 1/8" S.A.E. 6 or 10 Splines Optional To Slide When Under Load. Chamfer Ends of Bore and Sides of Splines 1/32" x 45°
Grind
Pitch Diameter
Rad.
Chamfer

GEAR DATA

Diametral Pitch	5-7
Pitch Angle, deg.-min.	61-11
Face Angle, deg.-min.	64-46
Chordal Thickness, in.[4]	0.3080
Corrected Pitch Depth, in.	0.1459
Addendum, in.	0.1429
Dedendum, in.	0.1785
Block Angle, deg.-min.	4-22
Pressure Angle, deg.	20

[4] Chordal thickness of 0.308 in. allows for 0.006-in. backlash.

18-Tooth Side-Gear for Case Mounting

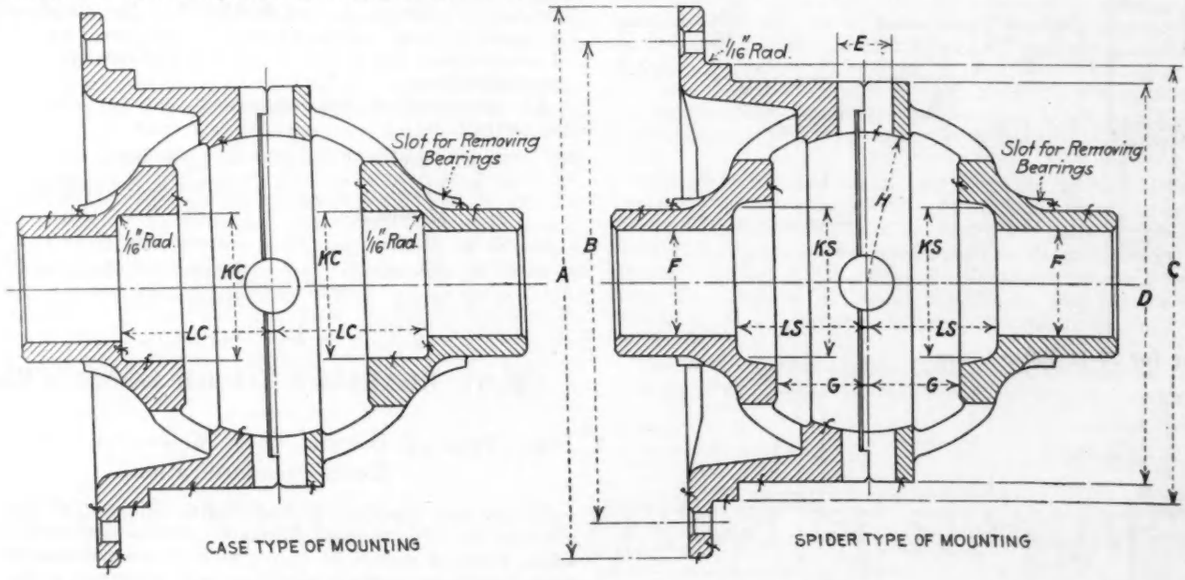

Run out 0.002" on Hardened Gear
Run out 0.008" maximum on Hardened Gear
Maximum Shaft Size 1 1/8" S.A.E. 6 or 10 Splines Optional To Slide When Under Load Chamfer Ends of Bore and Sides of Splines 1/32" x 45°
Grind
Pitch Diameter
Chamfer

GEAR DATA

Diametral Pitch	5-7
Pitch Angle, deg.-min.	60-57
Face Angle, deg.-min.	64-55
Chordal Thickness, in.[5]	0.3093
Corrected Pitch Depth, in.	0.1453
Addendum, in.	0.1429
Dedendum, in.	0.1785
Block Angle, deg-min.	4-57
Pressure Angle, deg.	20

[5] Chordal thickness of 0.3093 in. allows for 0.0060-in. backlash.

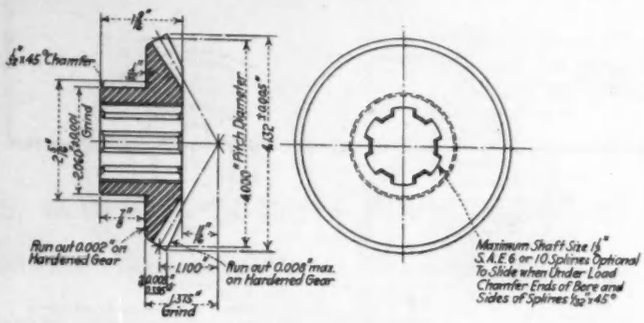
Two-Piece Case for Spider and Case Side-Gear Mountings



CASE DIMENSIONS FOR SPIDER AND CASE SIDE-GEAR MOUNTINGS

Model	*A*	*B* ±0.003	Number of Holes	Drill Size	*C* +0.000 −0.002	*D*	*E* ±0.001	*F* Maximum	*G* ±0.001	*H* ±0.001	*KS*	*LS*	*KC* +0.0015 −0.0000	*LC*
1	7⅝	6.625	10	21/64	6.000	5½	0.750	1 1/16	1.283	2.079	2 1/16	1 13/16	2.0000	2⅛
2	8⅛	7.125	12	21/64	6.500	6	0.750	1 1/16	1.377	2.315	2 1/16	1⅞	2.0630	2⅜

20-Tooth Side-Gear for Case Mounting

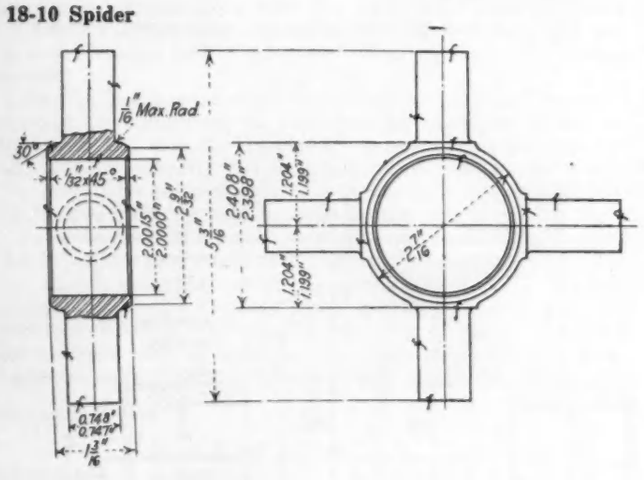

Run out 0.002" on Hardened Gear
Run out 0.008" max. on Hardened Gear
Maximum Shaft Size 1⅛" S.A.E. 6 or 10 Splines Optional To Slide when Under Load Chamfer Ends of Bore and Sides of Splines 1/32" x 45°
Grind
Pitch Diameter

GEAR DATA

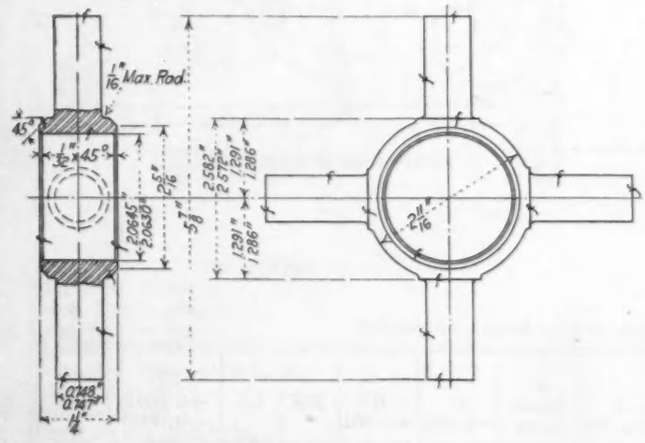
Diametral Pitch	5-7
Pitch Angle, deg.-min.	61-11
Face Angle, deg.-min.	64-46
Chordal Thickness, in.*	0.3080
Corrected Pitch Depth, in.	0.1459
Addendum, in.	0.1429
Dedendum, in.	0.1785
Block Angle, deg.-min.	4-22
Pressure Angle, deg.	20

*Chordal thickness of 0.308 in. allows for 0.006-in. backlash.

18-10 Spider



Spider for 20-11 Ratio Gears



CLUTCH STANDARDIZATION IMPRACTICAL

Transmission Division Discontinued Subject Because of Changes in Design

The standardization of clutch housings was undertaken over a year ago at the request of clutch manufacturers who were of the opinion that standardization would be highly advantageous to the clutch manufacturers and users. A preliminary recommendation was drawn up early last year and published in the May, 1923, issue of THE JOURNAL on p. 488. The dimensions, the standardization of which was considered necessary to obtain interchangeability, were

(1) The distance from the flywheel face to the rear throw-out position of the clutch sleeve

(2) The position of the throw-out yoke for the pull-sleeve type of clutch

It was recognized by the Subdivision that the greater the distance from the flywheel to the rear throw-out position, the greater the weight of the housing and the consequent overhang of the transmission, which would work a decided hardship on the large producers. A dimension of 6⅜ in. was therefore selected. Dimensions of 1½ and 1⅞ in. were proposed for the location of the throw-out yoke, these dimensions being from the center-line of the crankshaft and the face of the flywheel housing respectively; these being selected as providing a satisfactory position that would also permit a reasonable pedal-ratio for both multiple-disc and single-plate clutches.

At a joint meeting of the Engine and the Transmission Divisions held at Chicago in October it was recognized that important changes in clutch design are taking place which tend toward shortening flywheel and clutch housings. As it was felt that the proposed standard, if approved, would not be adopted in practice, it was decided that the standardization of clutch housings should be discontinued until the push-type of clutch shall have been developed sufficiently to warrant standardization.

The personnel of the Subdivision that has been studying the subject, is

D. E. Gamble, *Chairman*	Borg & Beck Co.
L. C. Fuller	Fuller & Sons Mfg. Co.
R. C. Merchant	Covert Gear Co.
H. W. Sweet	Brown-Lipe Gear Co.
C. E. Swenson	Mechanics Machine Co.
C. G. Wood	Hoosier Clutch Co.

PILOT BEARINGS TO BE CONSIDERED

Plain Type of Bearing Used to Greater Extent and Merits Standardization

At the last meeting of the Engine Division it was considered that the present standard for the disc-type of flywheel housing should be extended to include dimensions for plain transmission-shaft pilot bearings inasmuch as the plain type of bearing is being used to a greater extent, superseding ball bearings for this application.

The present standard specifies a 2.0472-in. bore in the flywheel web and a 1¾-in. minimum diameter and a 1/16-in. minimum depth for the counterbore in the crankshaft, which are considered satisfactory for both ball and plain pilot-bearings. The Engine Division is therefore obtaining information from engine builders, as well as from passenger-car and motor-truck companies building their own engines, as to

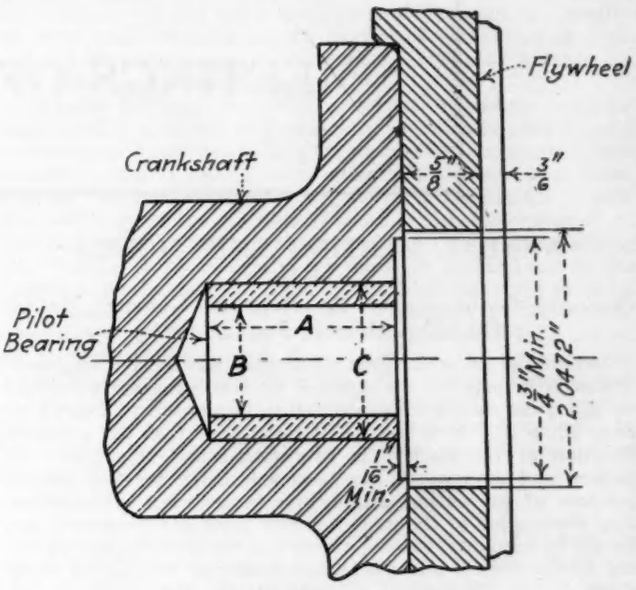
current practice for plain bearings in order that they may be in a position to make a recommendation covering dimensions *A*, *B* and *C* shown in the accompanying illustration.

FISHER HEADS NEW SUBDIVISION

At the October meeting of the Engine Division, the Subdivision on Poppet Valves was reappointed because of changes in business connection of several of the original Subdivision members. The original Subdivision was appointed in August, 1922, and presented a preliminary report that was printed in the April, 1923, issue of THE JOURNAL on p. 406. The new personnel of the Subdivision is

J. B. Fisher, *Chairman*	Waukesha Motor Co.
L. F. Burger	International Harvester Co.
Robert Jardine	Rich Tool Co.
S. O. White	Warner Gear Co.

The preliminary report is to be submitted to valve and engine manufacturers for comment in order that the Subdivision members may be in a position to revise it to meet the consensus of opinion as to the best engineering practice. Chairman Fisher is of the opinion that the dimensions should be limited to those absolutely necessary to obtain interchangeability of valves, regardless of whether they are made of iron, steel or any other metal.



PLAIN PILOT BEARING DIMENSIONS

DECEMBER COUNCIL MEETING

THE meeting of the Council held on Dec. 17 in New York City was attended by First Vice-President Crane, Second Vice-President Masury and Councilors Gurney, Scott and Scaife. H. L. Pope and M. P. Rumney, nominees for the 1924 Council, were also present.

The financial statement as of Nov. 30, 1923, showed a net balance of assets over liabilities of $146,404.54, this being $21,777.88 more than the corresponding figure on the same day of 1922. The net revenue of the Society for the first 2 months of the current fiscal year amounted to $38,790.19. The operating expense during the same period was $33,980.75.

Forty-seven applications for individual membership and one for affiliate membership were approved. The following transfers in membership grade were made: From Junior to Member, Charles Henry Boone, Charles J. Faber, C. S. Kegerreis, Edwin M. Post, Jr., John Wiggers, Willard R. Vohrer, Kenneth J. Boedecker, John T. Liggett, Philip L. Scott; Member to Service Member, H. A. Knox; Foreign Member to Member, Mario L. Luiggi; Junior to Associate, James B. Franks, Jr., J. Charles Hooper, Carl R. Chrisman, Paul Ehlers, Walter F. Babcock; Associate to Member, Raymond W. Dunster, T. W. Farnsworth, Jack B. Davis; Junior to Foreign Member, E. H. Siddeley; Associate to Foreign Member, Frederick J. Hughes.

It was reported that up to Dec. 15, 1923, 713 applications for membership, including student enrollment, had been received during 1923, as compared with 835 received during 1922.

The following additional appointments to the Motorboat Division of the Standards Committee were approved: Thomas D. Bowes, William H. Hand, Jr., John H. Wells and Wilbur H. Young; also representatives from following companies: Durkee & Co., Geo. B. Carpenter & Co., Rostand Mfg. Co., Society of Naval Architects and Marine Engineers, W. & J. Tiebout, Wilcox Crittenden Co. and E. J. Willis Co.

The next meeting of the Council will be held on Jan. 10 in New York City.

ON THE NATURE AND EFFECT OF STANDARDS

STANDARDIZATION is arbitrary. That is the basis on which it starts. The question is this: If we give due consideration to the proper claims of all interested parties, is this arbitrary standardization worth while? If so, the question is really: What does such arbitrary standardization lead to in the relations between the supplier and the user?

I will grant that the commercial tendency is to supply all the demands of the users and, as one would expect, a consequent large demand. I represent two organizations that last year undertook to standardize the steam turbine. We started by trying to standardize the sizes of the steam turbine. We had the builders with us, and they were as usual between the devil and the deep sea. The users demanded certain very closely spaced sizes, and the builders naturally wanted to meet the users' demands. On the other hand, the users were complaining about the cost of the unit.

It is obvious that if a man makes 6 sizes over a given range instead of 12, the units will be cheaper in the case of such things as steam turbines; and we finally agreed upon certain standards, and sooner or later, if I am not mistaken, those sizes will be the standards of steam turbines in this Country.

It does not mean that you cannot buy other sizes, but that when you want a steam turbine you will buy the standard or pay the burden that you put on the industry.

It is not a question of whether some of us want standardization and some of us do not. Standardization is forced on us. If we are to survive commercially we must standardize.—C. F. Hirshfeld, before the American Society of Mechanical Engineers.

MEETINGS OF THE SOCIETY

ANNUAL MEETING THIS MONTH

National Gathering to Be Held in General Motors Building, Detroit, Jan. 22 to 25

Regardless of what your particular automotive engineering activity may be, the Annual Meeting program published on this page should influence you to be present in Detroit on Jan. 22 to 25. It is generally recognized that the primary function of the Society is educational and this group of papers and discussions has been assembled for the specific purpose of presenting worthwhile engineering information. Any description of the papers in this brief announcement can hardly be adequate, but the names and the professional standing of the several authors should suffice as evidence of their value.

Do not forget that reduced-fares can be secured on the railroads during the Annual Meeting period. Details of the plan are given on p. 80. If you have not made hotel reservations, this should be attended to without delay. Write direct to the Hotel Statler, the Tuller or the Wolverine and say that you will attend the Annual Meeting of the Society of Automotive Engineers; this will assure special attention. Then there is the matter of a reservation for the Carnival. This gay party is described on p. 80; application for tickets should be forwarded early if you wish to secure the choice table locations.

New S.A.E. Standards to be Presented

Many important recommendations of new S.A.E. Standards will be presented for discussion at the annual meeting of the Standards Committee of the Society, which opens at 10.30 a.m., Eastern Standard time, Tuesday morning, Jan. 22. Read these additions and revisions as reported on p. 37 of this issue and come to the meeting prepared to discuss them. Discussion of the Standards reports will continue into the afternoon session of the Committee, which will begin at 2 o'clock.

For the Body Engineers

Men engaged in the design and construction of passenger-car bodies will find a very complete program arranged especially for them. Two Body Engineering Sessions will be held, the first on Tuesday afternoon and the second on Wednesday afternoon. New developments in the use of casein glues for motor-car bodies will be presented by W. A. Henderson, a body engineer of long experience, who is now connected with the Casein Mfg. Co. Arthur T. Upson and Leyden N. Ericksen, of the Forest Products Laboratory, will read a paper on woods for automobile bodies and offer some suggestions on standard sizes of lumber, with the intention of reducing body costs. K. L. Herrmann, of the Studebaker Corporation of America staff, will read a paper on leather for automobile trimming, devoted in large part to a description of the testing methods used to determine the important qualities of hides in the inspection department.

In the Wednesday session, Prof. Edwin F. Baker, of the University of Michigan, will report the results of research to increase the durability of nickel-plating on steel, describing a valuable new process that has proved successful in practice. A plant using this process will be inspected directly after the meeting. Charles Widman will give an illustrated description of a new type of closed body, the panels of which are enameled and baked before being mounted on the wooden body structure. H. T. Strong, of William Wiese & Co., will tell something about the newer trimming materials for closed cars and discuss style tendencies. W. H. Jones of the C. R. Wilson Body Co., will lead a discussion on the effects of drying-oven temperatures on wooden body structure.

Aeronautical Session

One of the outstanding papers of the Annual Meeting will be read in the Aeronautical Session, on Tuesday afternoon, by Starr Truscott. This will be a technical description of the engineering work on which the design of the Navy airship Shenandoah was based. It will not be a mere description of the ship itself, but rather a presentation of the intensely valuable research work done by the Navy and the industry to surpass the technique of the German engineers who pioneered the development of the rigid type of airship. Reliability of engines for aircraft will be discussed in a paper to be read by George J. Mead, chief engineer of the Wright Aeronautical Corporation. Lieut. A. J. Lyon, of the McCook Field engineering staff, will contribute a paper on light alloys for use in airplane engines. It is possible that other aeronautical papers will be secured, in which case an additional session will be held Wednesday afternoon.

Ordnance Talks and the Business Session

The session on Tuesday evening will be addressed by two of the Army's leading ordnance officers, Brigadier-General J. W. Joyes and Brigadier-General C. L'H. Ruggles. They will describe the latest engineering progress made in ordnance materiel, particularly those units that are automotive and would be built by our industry in case of a National emergency. These talks will be profusely illustrated with motion pictures showing the guns, tanks and other ordnance materiel in actual use.

Directly following the talks by the Ordnance officers, the Annual Meeting of the Society will be called to order. President Alden and the president-elect will address the members on the work of the past year and that planned for 1924. One of the most important matters before the Society is the relation of the parent body to the several Sections. There is a demand in some parts of the Country for re-establishment of the old form of Section Associate with somewhat more stringent regulations. It is also desired by some Section workers that the Society dues be raised to make all members living in Section territories members of the Sections without payment of local dues. Undoubtedly these two questions will be discussed at the Business Meeting and that makes it doubly important that those having views to express on either of these matters be present to participate in the discussion.[1]

Truck and Motorbus Transportation

One of the sessions on Wednesday afternoon will be devoted to a discussion of the coordination of railroad and motor-truck transportation. This discussion will be based upon the recent report of the special committee of the United States Chamber of Commerce, which studied with great care the best means of using the motor truck as an adjunct of the Nation's rail and water transportation media. The discussion will be opened by R. C. Wright, general traffic manager of the Pennsylvania Railroad System. Many other men prominent in the transportation field have agreed to be present and submit their views, among them L. R. Gwyn, of the American Railway Express Co., and Arthur T. Waterfall, of Dodge Bros. This session will appeal to executives and engineers engaged in the design and the construction of motor trucks, as well as to the transport engineers who are operating large fleets of freight vehicles.

[1] See remarks on p. 2.

Motorbus design, operation and application will be the topic of the session on Thursday afternoon. The Society has been especially fortunate in securing R. W. Meade to present the opening paper. Mr. Meade pioneered the introduction of the motorbus in this Country and has established successful lines on Fifth Avenue in New York City, in Detroit, Toronto, St. Louis and other cities. An eminent public-utility engineer, J. E. Emory, will read a paper on the proper place of the motorbus in urban transportation. In addition, the following authorities have agreed to be present and discuss the papers: E. E. Moore, of Cleveland; Vincent Keenan, of Providence; R. E. Plimpton, of *Bus Transportation*, New York City, and Boyd V. Evans, of Detroit.

Brakes and Braking Performance

Copyright by C. M. Hayes

HENRI PERROT

Henri Perrot, a pioneer in four-wheel brake development in Europe, will address the members at the Brake Session, which will be held Wednesday morning. He will give a carefully prepared paper setting forth good and bad points in the design of four-wheel braking systems, so that engineers may profit by his broad experience and avoid design errors. W. S. James, of the Bureau of Standards staff, will discuss in a comprehensive way the results of the Bureau's extensive study of automobile braking performance. Due to the use of ingenious instruments developed at the Bureau of Standards, these tests are most enlightening. The test results and observations are reliable and unprejudiced. Mr. James will give demonstrations of a recording decelerometer and other interesting apparatus at the meeting. George L. Smith will read a paper on brake equalization.

Fuels, Engines and Kindred Subjects

No automotive engineering meeting would be complete without papers on the all-important subject of fuel. One of the simultaneous sessions on Thursday afternoon will be the occasion of the presentation of papers relating to this field. A. M. Dean, of the Swan Carbureter Co., will read a paper describing the unconventional type of manifold developed by John W. Swan, the paper including quantitative tests to indicate the particular advantages of this design. C. S. Kegerreis, of Purdue University, will offer a paper on the metering characteristics of present-day carbureters as compared with the ideal carbureter. Prof. G. A. Young and J. H. Holloway of the same institution will pesent the results of their research work on the control of detonation at high compression-pressures. N. S. Diamant will read a paper on automobile radiator design.

Thomas Midgely, Jr., will open the Thursday morning session with a paper on detonation control and give demonstrations of flame travel in a single-cylinder engine that has quartz inserts in the cylinder walls so that the actual flame can be observed while the engine is in operation. Roger Birdsell, one of the survivors of the deplorable explosion at the Bureau of Standards laboratory, will read a paper giving the results of further research work at the Bureau in the matter of fuel volatility. Part of his conclusions will be based on the results of tests that were in progress at the time of the explosion. His paper will be supplemented by a report of the Society's Research Department on the same subject. Both of these papers will discuss the matter of crankcase-oil dilution and its relation to fuel volatility. An experimental engine of the constant-compression type will be described in a paper by C. E. Sargent, as the concluding paper of this session.

Production Sessions

It is not possible to announce the complete program for the production meetings at this time, but present plans call for the conduct of two sessions on Friday, one in the morning and another in the afternoon. Papers will be read by Gordon Lefebvre, of the Chevrolet Motor Co.; Thomas Nadin, of Rolls Royce of America; T. B. Fordham, of the Delco Light Co.; A. A. Brown, of the Chandler Motor Car Co.; a representative of the Cleveland Automobile Co., and others. This program will be announced in the special issue of *The Meetings Bulletin* that will be mailed from New York on Jan. 12.

NON-MEMBERS MUST PAY FEE

Will Be Required to Pay for Privilege of Attending Detroit Sessions

All non-members of the Society who wish to attend the sessions at the Annual Meeting in Detroit will be required to pay a registration fee of $2 for this privilege. Members will be entitled to attend all of the sessions without charge, as in previous years. The Detroit Meeting will cost the Society a substantial sum of money and it is logical that those who wish to secure its benefits and who do not contribute to the support of the meeting through the payment of dues should be expected to pay a share of the expense. Admission to all sessions will be restricted to those wearing buttons that will be issued at the registration desk. This new regulation should be borne in mind by members who plan to bring non-member guests to the meeting. The fact that a non-member is a guest of a member will not entitle

Arrangement of Sessions at Annual Meeting

	Tuesday, Jan. 22	Wednesday, Jan. 23	Thursday, Jan. 24	Friday, Jan. 25
Morning	Registration Standards Committee Meeting	Brake Session	Fuel and Engine Session	Production Session
Afternoon	Standards Committee Meeting Body Session Aeronautic Session	Truck Session Body Session Fuel and Engine Session	Bus Session	Production Session
Evening	Body Engineers' Supper Talks on Army Ordnance Annual Business Meeting	The Carnival		

him to admission without the payment of the $2 fee. This fee will be the same whether a non-member attends all sessions or only one of them.

REDUCED RAILROAD-FARES

Society members and their dependents living within the shaded regions on the accompanying map can purchase return tickets from the Annual Meeting in Detroit at half-fare. Note the following directions carefully:

(1) Buy tickets to Detroit between Jan. 18 and 24
(2) Ask the agent for a *Reduced-Fare Certificate*, not a receipt
(3) Present signed certificate for validation at the Transportation Desk in the General Motors Building, Detroit, immediately upon arrival in the city

HALF-RATE RETURN ZONE
Members Living in the Shaded Area Who Attend the Annual Meeting at Detroit Can Purchase Return Tickets for Themselves and All Dependent Members of Their Families Who Accompany Them

(4) Certificates will be validated from Jan. 22 to 25 in Detroit. Do not plan on returning before the first of these dates as no certificates can be validated before 250 have been received. Arrive before the last date given as no certificates can be validated later
(5) Validated certificates entitle you to one-half fare returning over the same route as you came, if purchased before Jan. 29 in Detroit
(6) Reduced-fare return tickets are not good on certain limited trains. Consult agent regarding this
(7) It must be understood that the reduction on the return journey is *not* guaranteed, but is contingent on the attendance of not less than 250 members and dependent members of their families
(8) The Society is held accountable under the Interstate Commerce laws for any violation of the agreement limiting the reduced-fare privilege to members and dependent members of their families. Regardless of any assurance given by local railroad officials or others, absolutely no certificates will be validated unless they are presented by persons whose membership is evidenced by our records. Applicants for membership are not considered as members

ORDER CARNIVAL TICKETS NOW

Ticket applications for that scintillating, spectacular and spell-binding event, the Carnival, flow into the New York City office without interruption in every mail. One thing is certain; this particular Carnival will assemble one of the largest social gatherings in the history of the Society. The moral to this tale is a simple one; get your tickets early. Remember that this will be a variation of the popular dinner-dance, with all guests seated at reserved tables. There will be many entertainment features and, of course, you want your party seated close to the center of things. That cannot be done for everybody and the natural result is the enjoyment of front-row advantages by the farsighted who buy tickets now.

Tickets can be ordered on the application blank mailed to all members on Dec. 18, or you can apply for them by letter if the blank did not reach you. The price for gentlemen is $6; for ladies $3. Tables seat 2, 3, 4, 5, 6, 8 or 10. Oriole Terrace, Detroit's finest dancing establishment, will play host to this gay party and the date is Wednesday, Jan. 23. We will see you amidst the balloons, confetti and bright lights—if you order tickets now and avoid disappointment.

DESIGN OF COAST-GUARD BOATS

Anti-Rum-Runners to Be Discussed at the Motorboat Meeting in New York City

Everyone engaged in the construction of motorboats, their engines and accessories is intensely interested in the proposed construction of a vast fleet of anti-bootleg motorboats of a high-speed type for the United States Coast Guard. President Coolidge recommended in his recent message to Congress that $20,000,000 be expended in adding to the Coast-Guard equipment, a major part of this fund to be used for the purchase of specially designed speed-boats to combat rum-running. Capt. Quincy B. Newman, chief engineer of the Coast Guard, will address the members at the Motorboat Meeting in New York City on Jan. 9, for the purpose of discussing with them the plans for the new equipment that will be needed if this appropriation is passed by Congress. His talk will be illustrated and he is anxious to have our members come to the meeting prepared to offer constructive criticisms of the proposed designs. In addition, George F. Crouch, well-known designer of motorboats, will read a critique of motorboat engine and equipment designs from the viewpoint of the naval architect.

Following the technical meeting, which will start promptly at 10:00 a. m., the Annual Motorboat Luncheon will be held. This is an informal social function arranged for the purpose of promoting acquaintance among motorboat men in general. Both of these gatherings will be held in the Hotel Commodore, Wednesday, Jan. 9.

BRAKES, TWOS OR FOURS?

Indiana Stages Bout with a Punch in Which Traffic Officers Participate

Few of the sessions of our Society require the presence of police officers, but the Dec. 6 meeting of the Indiana Section would have been incomplete without them. The 150 members and guests who gathered for the dinner that preceded the meeting were duly impressed with the dignity of the occasion when they beheld officers Owen and Sweeney in uniform seated at the speakers' table, and several of their collagues scattered among the crowd.

After the tables had been cleared and about 150 more members admitted, Chairman F. F. Chandler announced that officer Owen would present his views on four-wheel brakes. This he did in no uncertain terms. But as he became well-launched in his very vehement tirade against the use of brakes on all four wheels, it was apparent that officer Sweeney was not in entire agreement with the views expressed. In fact, he interrupted the speaker to announce that Owen was not speaking for the Indianapolis police department but for himself, and he added, "Owen is not qualified to speak on this subject for he has never driven anything but a Ford." This remark was the unkindest cut of all for Owen, who stepped up to Sweeney, and they were off. A very spirited fistic encounter was finally quelled by a fellow officer assisted by members of the audience, and Sweeney and Owen, down but not out, returned to their places.

Introducing the next speaker Chairman Chandler remarked that the committee had decided to have the officers there to show the members what to expect of the discussion that was to follow.

Tests of Brake Performance

Under the direction of W. S. James, the Bureau of Standards has gathered a considerable quantity of extremely interesting and valuable material on braking characteristics of cars equipped with various types of brakes and tires. This work was designed as a basis for simple tests of brake performance which can easily be applied by traffic-control authorities and other interested parties. The data have been obtained with a recording decelerometer designed and constructed at the Bureau and described in detail in the December issue of THE JOURNAL, on p. 499.

Indicating Decelerometer

In addition to the recording model Mr. James showed a decelerometer of the indicating type with scale graduations in feet-required-to-stop from a speed of 20 m.p.h. In principle of operation this instrument is identical with the recorder, but without the recording device it is somewhat smaller and simpler in construction. A pendulum suspended from the top transmits its motion through a suitable linkage to the indicating pointer; means for damping are provided. In testing a car it is necessary only to place the decelerometer on the floor and note its indication as the car is brought to a stop.

Mr. James repeated the paper presented before the New England Section in November, an abstract account of which will be found on p. 522 of the December issue of THE JOURNAL.

Advantages of Hydraulic Brakes

One of the great advantages of hydraulic brakes mentioned by Chester S. Ricker, of the Duesenberg Auto & Motors Co., was the elimination of difficulties encountered in mechanically connecting the brake pedal with the front wheels. These were stated as, (*a*) the effect of spring-deflection on brake application, (*b*) the effect of axle rotation under brake torque, and (*c*) the effect of the wheels turning when steering. Calling attention to the fact that the hydraulic type maintains the connection between brake and frame by a flexible rubber tube reinforced with steel, Mr. Ricker explained how this type avoids the most important difficulties above mentioned and assures the equalized application of pressure to the brakes. He stated that only by the most expensive equipment could mechanically operated brakes be made to give the uniform braking application at all steering angles characteristic of the hydraulic type.

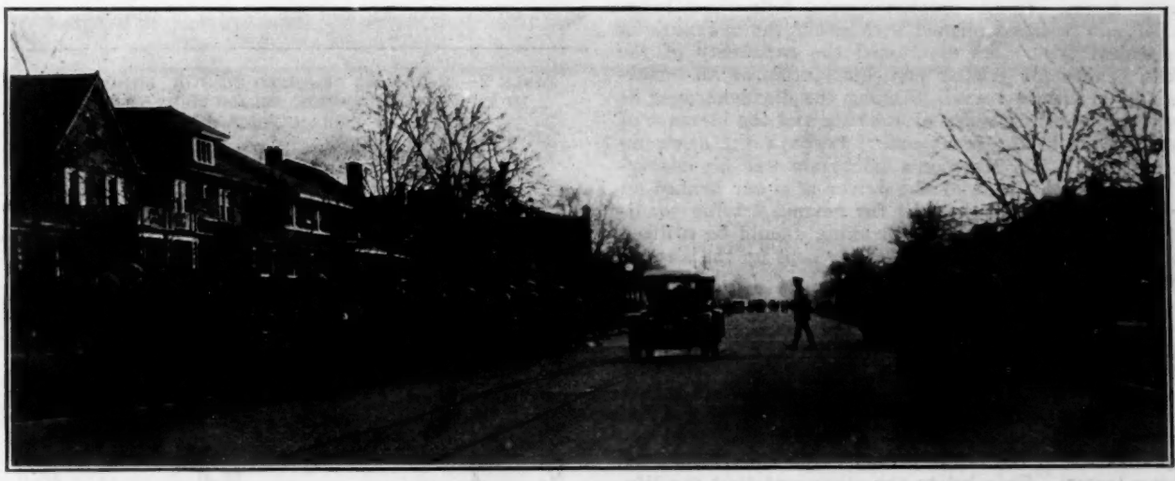
CHESTER S. RICKER HOWARD C. MARMON

Toggle Action Explained

As regards ease of operation, the brakes described take advantage of a toggle action giving a variable leverage. Thus, for a pedal pressure of 55 lb. applied uniformly during the stroke the resulting pressure is, say, 100 lb. per sq. in. at the first inch of movement and 500 lb. per sq. in. when the pedal reaches the floor. Unlike the mechanical brakes this hydraulic type is operated by a pedal pressure that is practically uniform throughout the stroke; the pedal return is also slower but the brakes are released promptly. The use of the toggle action above described was claimed to make unnecessary any form of servo-mechanism.

Other Design Features

Uniformity of pressure-application by hydraulic means, fully enclosed front-wheel brakes tending toward uniformity of brake torque because of protection from dirt and moisture and careful general design were mentioned as the most important factors in the installation. It was also brought out that the hydraulic brakes described have automatic adjustment and that the most logical method of application has been adopted, namely, ordinary service application for the first part of the pedal travel and emergency application for the last part of the pedal travel. Use of the tubular front axle was advocated because of its lightness for a given strength and because of its ability to take the car-load and brake torque reaction satisfactorily.



THE BRAKE DEMONSTRATION AT INDIANAPOLIS ON THE AFTERNOON OF DEC. 6

In Connection with the Round-Table Discussion of Four-Wheel Brakes at the Meeting of the Indiana Section, a Demonstration of the Relative Stopping Ability of Two and Four-Wheel Brakes Was Held in the Afternoon. Balloon and Regular Pneumatic Tires and Hydraulic and Mechanical Brakes Formed Part of the Equipment of the Cars Tested Which Were Stopped from Initial Speeds of 20, 25, 30, 35 and 40 M.P.H. The Skid Marks from a Previous Test Should Be Noted Directly in Front of the Car That Is Being Tested

Steering and Equalization

In analyzing the effect of two and four-wheel brakes on steering, Mr. Ricker stated that although one cannot steer a car with front wheels locked neither can one manage the car with rear wheels locked when it begins to skid; under similar conditions this would take place sooner with the two-wheel than with the four-wheel brakes. However, he stated that easy steering is still maintained with the front-wheel brakes applied with a reasonably high pressure and that gradual application is as easily accomplished as on any car. The tire wear was stated to be greatly reduced with four-wheel brakes.

In Mr. Ricker's belief the braking on the front and the rear wheels should be equal. The argument that the front axle takes 40 per cent of the load and the rear axle 60 per cent was stated as true for loaded cars only, a condition that obtains for only a part of the time. Thus it was felt that the brakes should not be designed for this condition. The shifting of load to the front axle was also mentioned to strengthen the statement.

Mr. Ricker concluded his paper with the following enumeration of advantages of hydraulically operated four-wheel brakes; (*a*) perfect equalization, (*b*) dual brake action range, (*c*) non-rattling mechanism, (*d*) automatic adjustment, (*e*) perfect braking at all steering angles, (*f*) equal application of brakes, front and rear and (*g*) uniform pedal-pressure requiring no servo-mechanism.

Mechanical Four-Wheel Brakes

In his argument in favor of mechanically operated four-wheel brakes John R. Cautley, now interested with Vincent Bendix in the Perrot type, gave a resume of foreign developments. He stated that with one exception all companies exhibiting at the recent Paris Salon had four-wheel brakes on one or more of their models. The majority of these were mechanically operated. The British show this year was said to have had 32 per cent of the cars thus equipped as against a showing of 10 per cent 1 year ago.

Mr. Cautley reported that the foreign cars which he had driven could be steered much more easily than American models. He believed that our engineers should devote greater attention to this feature, as the four-wheel brakes and balloon tires demanded it.

Mr. Cautley stated that his connection with the problems of braking had been very recently established and that he hoped later to be able to report in greater detail the advantages of the mechanical type in which he is interested.

The Discussion

Howard Marmon opened the discussion with a summary of braking problems. In his opinion a good four-wheel brake installation can be accomplished with either the hydraulic or the mechanical type. He mentioned the capability of the four-wheel brakes for greater heat dissipation as an important item in mountain travel. Among the disadvantages he mentioned the added difficulty of steering and the increase of unsprung weight in the front axle. Perhaps the most important feature of Mr. Marmon's discussion was his conception of the proper attitude of the driver of a car braked on all four wheels. He thought that for normal driving conditions only the normal amount of braking should be utilized and that the reserve capacity should be "kept up the sleeve" for emergency application.

Mr. James decried the manner in which the advertising and the sales departments are talking so much about the reduced stopping distance with the new brakes. Granted that such claims are true, he felt that it was harmful to stress this point to the detriment of the more sound argument of better and safer stopping within normal distances even under adverse conditions. He called attention to the difference between equalization of the brake pressure and equalization of the braking torque. This led to the statement that the life of brake-lining has been increased in 3 years by about 300 per cent, with a possibility for even greater improvement as to both life and braking effectiveness.

The question of reduced insurance for cars with four-wheel brakes was raised. It was stated that as yet the insurance companies in general are not willing to grant a reduction.

As for cost of manufacture opinions differed. It seemed to be the feeling that the hydraulic and the mechanical types would cost about the same but with the possibility that the former might be somewhat cheaper.

O. C. Berry enumerated some of the advantages and disadvantages of both types of brake. He mentioned the criticism of more difficult steering and actual interference in negotiating curves with the wheels locked. He argued that any car was unmanageable with the wheels locked in a skid and felt that the better and the safer stopping with the additional brakes was favorable to them.

W. G. Wall stressed the importance of carefully designing the front axle to withstand the braking torque. He believed that the use of servo-mechanisms or "labor savers" would increase. Recalling Mr. James' remarks about the desirability of torque rather than pressure equalization he wondered if much attention need be given to equalization between right and left wheels, inasmuch as the torque reaction would be different regardless of the pressure equalization.

From the discussion it seemed that the "two-wheel" advocates were content to let their brakes speak for themselves.

TABLE 1—AVERAGE STOPPING DISTANCES FROM VARIOUS INITIAL SPEEDS

Initial Speed, M.P.H.	Distance Required To Stop, Ft. Two-Wheel Brakes[2]	Four-Wheel Brakes[3]
29	30	12
30	74	31
40	122	54

[2] Average deceleration, 10½ ft. per sec. per sec.
[3] Average deceleration, 22½ ft. per sec. per sec.

Braking Demonstration Attracts Crowd

In the afternoon preceding the meeting a very successful demonstration of both two- and four-wheel braked cars was held; several were equipped with balloon tires, and both mechanical and hydraulic brakes were represented. Stopping distances from initial rates of 20, 30 and 40 m.p.h. were measured, and Mr. James obtained records of the stops with his recording decelerometer. He gave the average results of the test presented in Table 1.

The complete results of the tests are given in Table 2. All of these tests were made over the same stretch of smooth dry asphalt. These tests give some indication of the comparative stopping ability of two- and four-wheel brakes, but they cannot necessarily be accepted as indicative of other factors of braking performance such as the tendency to skid or the effect on the steering and the control of the car. Except as

TABLE 2—DISTANCES REQUIRED TO STOP THE CARS TESTED IN THE DEMONSTRATION ARRANGED BY THE INDIANA SECTION AT INDIANAPOLIS ON DEC. 6, 1923

Car	Brakes on How Many Wheels	Distance in Feet and Inches Required To Stop from Speeds of 20 M.P.H.	25 M.P.H.	30 M.P.H.	35 M.P.H.	40 M.P.H.
A	2	30–9		86–6		134–0
B	2			77–11		125–6
C	2	29–9		71–11		
D[4]	2	29–9		64–2		114–2[5]
E	4			23–10		40–6
F	4			37–11		62–6
G[4]	4			21–0		44–0[5]
H	4			25–0		61–0[5]
K	4	9–9		39–0		64–0
L	4	14–7		26–10		60–5
M[4]	4		23–0	88–10	38–0	
N	4			17–0		48–0
O	4	12–3		40–0		
P	4			38–0		

[4] This car was equipped with balloon tires.
[5] Side-skid occurred in stopping.

indicated, all cars skidded straight ahead with locked wheels. Several stops were subsequently made on the same surface when wet. Under these conditions no difference in the brake performance was apparent. Regular pneumatic-tire equipment was used on all cars, except for cars *D*, *G* and *M*, which used balloon tires.

Great credit is due the following members who were responsible for one of the most successful Section meetings ever held by our Society: F. F. Chandler, chairman; O. C. Berry; George T. Briggs; W. G. Wall and G. A. Weidely. Harlow Hyde assisted the committee with the publicity and general arrangements.

STORAGE-BATTERY MAINTENANCE

Conditions and Care Necessary to Obtain Effective Service and Long Life

Automobile Storage-Batteries, Their Operation and Care was the subject discussed by T. R. Cook of the Westinghouse Union Battery Co. at the December meeting of the Metropolitan Section held at the Automobile Club of America on Dec. 13. Notwithstanding the unfavorable weather about 80 members and guests were present when the meeting was called to order by Vice-Chairman C. B. Veal. The discussion following the reading of the paper was participated in by Bruce Ford, of the Electric Storage Battery Co.; W. E. Holland, of the Philadelphia Storage Battery Co.; A. D. T. Libby, of the Splitdorf Electric Co.; C. E. Allen, of the Edison Storage Battery Co.; Roger Chauveau, of the Metropolitan Battery Service Co., and H. M. Crane. Mr. Cook closed the discussion by replying to numerous questions that had been written on cards provided for the purpose.

A healthy storage-battery, in which the generator input is properly proportioned to the service required, said Mr. Cook, in part, will operate with entire satisfaction provided it is supplied with the requisite amount of distilled water, is kept free from dirt and corrosion and its terminals maintain good contact. Most troubles occur after a battery has finished its useful life, the length of which depends upon its design, the quality of the materials of which it is constructed, the care given to it and the relation of the current put in to that taken out. With proper care the useful life of a battery should be from 4 to 5 years. A commercial compromise, however, is frequently necessary, and is determined by the relative importance of the considerations of weight, size and cost. By keeping these factors at the minimum a smaller battery working at a higher rate is the usual result, but the useful life is reduced to from 1½ to 3 years and the battery requires closer attention. Although the longest life is obtained by using a constant-potential charging machine, here again considerations of cost and expert attention enter and another compromise has been made by substituting the third-brush machine, a constant-current apparatus with a tapering rate of charge as the speed of the car increases. Extremes of service affect the life of a battery and vary from that of cars used only for touring by day, where the runs are long and the stops infrequent, to that of cars used by doctors, for instance, which are in service by day and by night, with many short slow runs and innumerable starts. The input from the generators also varies greatly. Whereas batteries are normally designed for an input of approximately 7½ amp. the range frequently is from 2 to 18 amp. The doctor's car, if equipped with the 2-amp. charger, would need recharging many times per month; if the tourist's car were equipped with the 18-amp. charger, the battery would undoubtedly burn out after 2 or 3 months of service. Excessive use of current due to a faulty carbureter or to a leak caused by a partial ground may drain the battery. Too great input by the generator is indicated by the demand for an excessive amount of water. To maintain batteries in their best condition, (*a*) the electrolyte should be kept from ⅛ to ¼ in. above the top of the separators, (*b*) the top of the battery should be kept dry and clean, (*c*) the contacts should be kept tight and protected with vaseline from corrosion, and (*d*) the generator should produce the proper amount of current for the use required.

In summing up, Mr. Cook said that the principal difficulties in the use of storage-batteries were due to faulty manufacture and abuse in service. He emphasized the desirability of adopting S. A. E. Standards, of providing battery compartments that would allow the use of sizes of battery larger than that originally installed and particularly the ability to take one of two standard sizes. No owner should ever be in a position where he cannot obtain a battery for his car from any service-station, no matter where he may be.

Mr. Holland commented on the troubles due to undersize batteries, the importance of protecting the battery from weather and dirt and of having it well supported and accessible.

Referring to his experience in the telephone business, Mr. Libby observed that batteries, in general, are not sufficiently charged; that usually not enough water is used; because of the patent situation, a voltage regulator is seldom used and manufacturers have been compelled to use the third-brush generator; this is less complicated and also less expensive; generator specifications have been accurately drawn and specifications for motor-generator and storage-battery installations should be expressed so that the buyer may know just what he is getting; recently he had ordered a new battery for his car but found on its arrival that the new battery was ¾ in. longer than the one originally installed; this necessitated several modifications of the car before it could be used; manufacturers should give these matters more careful consideration.

Mr. Crane compared the use of storage-batteries to that of

Schedule of Sections Meetings

JANUARY

2—MINNEAPOLIS SECTION—Service Meeting—Talks by local dealers' service-men

17—INDIANA SECTION—Engine Performance—H. L. Horning

22—DAYTON SECTION—Research in Improving, Handling and Utilizing Rubber Latex—B. J. Lemon

22—NEW ENGLAND SECTION—General Truck Service—Arthur B. Cumner

The following Sections will not hold meetings in January, but will concentrate on the Annual Meeting of the Society at Detroit, Jan. 22 to 25: Cleveland, Detroit, Metropolitan, Mid-West, Washington and the proposed Milwaukee Section.

FEBRUARY

4—BUFFALO SECTION—Engines for Oil vs. Oil for Engines—L. H. Pomeroy and A. Ludlow Clayden

14—INDIANA SECTION—Engine Tests and Research Work—C. P. Grimes

lubricating oil. Although manufacturers are familiar with the distinctions between the different kinds, users are not so well informed. He asserted that the battery in the car he is using at present has never been repaired and that the one in another car used since 1916 has required no repairs. Batteries sometimes fail because of the generator's not being sufficiently active. There is no danger of overcharging a battery that is kept full of water. Batteries placed under the seat look well but are not accessible. For this reason several makers are now placing them in the fenders.

Replying to questions, Mr. Cook, in closing the discussion, brought out the following points: During the last year the output of batteries per pound of weight has increased 15 to 20 per cent; the product is also more uniform; the capacity at 0 deg. fahr. is approximately 15 per cent; buckling is caused by the active material's expanding more than the grid; poor gasoline is the cause of the greatest trouble in winter; in most States the water is fit to use; that of Cleveland and Lake cities is especially good; some water, however, containing iron is not fit; rubber battery cases are advantageous; when doing an excessive amount of touring it is advisable to keep the lights burning.

MOTOR-VEHICLE VIBRATION

Two of Its Phases Discussed at Minneapolis Section Meeting

Referring briefly to the more simple forms of engine as a basis for an analysis of the predominating types of automotive engine, Amos F. Moyer, engineer of the Toro Mfg. Co., then discussed the subject of Engine Balance at the Minneapolis Section meeting on Dec. 5. His paper was along the same lines as those of the previous one on New Principles in Rotative Balance, published in THE JOURNAL last year.[5] Following its presentation and discussion, V. V. VanNattan, designer for the Superior Products Mfg. Co., Minneapolis, read his paper on the Air Cushioning of Automobiles and this was discussed also. An engine that is out-of-balance and unsuitable or inadequate springs will each contribute toward excessive vehicle-vibration.

Mr. Moyer's paper was received with keen interest, the subject being treated in as non-technical a manner as possible. It dealt particularly with internal-combustion-engine balance ranging from single-cylinder to 8 and 12-cylinder types. An analysis was made in each case of the various forces to be dealt with, and the extent of balance obtainable was well pointed out, especially so when the complex nature of the subject is considered. Mr. Van Nattan disclosed problems to be met in design and the service to be expected with several types of pneumatic shock-absorber. Both papers were productive of interesting remarks and opinions in the discussion that followed their presentation.

HOW TO BALANCE ENGINES

Mr. Moyer said in part that the balancing of an engine crankshaft is primarily a matter of design and secondarily one of production methods, the object being to obtain rotative balance with certain allowances made for external considerations. While it is possible to place any unsymmetrical body in perfect rotative balance by the attachment at two points only of suitable weights or the removal of a suitable amount of material, and while parts sometimes are designed intentionally to be out-of-balance to absorb forces from other parts, Mr. Moyer stated that the design of a balanced part such as a crankshaft is greatly facilitated by observance of the following rules:

(1) Let the unbalanced structural portions of the member, such as the crankpin and the arms, be of symmetrical form with respect to a transverse plane containing the center of the reciprocating inertia forces

(2) Counterbalance, about the axis of rotation, by weights having a gravity moment equal to that of the unbalanced portions, or by the disposition of like structural members, and take care to observe Rule (1)

(3) Space the crank pairs equally about the circumference with more than two divisions, taking care to observe Rules (1) and (2) for rotative balance

For a single cylinder, Rule 1 would call for a center-crank type of engine having equal arms at the respective ends of the crankpin.

Rule 2 calls for two counterbalance weights opposite the crank throw and as close together as will clear the connecting-rod, for a single-cylinder engine. The gravity moment of these weights about the journal center will equal the combined gravity moments of the crankpin and the crankarms if the shaft alone is to be in rotative balance. Such counterbalancing weights or members will exert less bending-moment on the shaft, if their longitudinal disposition is as short as possible, and will produce less elastic distortion if the journal bearings are disposed as frequently as possible.

But the connecting-rod and the piston possess weight. That of the piston is reciprocative, but that of the connecting-rod is reciprocative at the small end and rotative at the big end. For analysis, the reciprocative weight of the connecting-rod can be taken as the weight at the center of the small-end eye when balanced horizontally over a knife-edge at the center of the big-end bearing. This, added to the weight of the complete piston, including the pin and the rings, gives the total weight of the reciprocating parts. The weight of the rod at the big-end center when balanced horizontally over the center of the small-end eye can be considered as rotative. The amount of its gravity moment at the radius of the crank-throw can be added to the amount of counterbalance on the crankshaft of an actual engine, or can be considered as counterbalanced by the big-ends of other connecting-rods in a multi-cylinder engine. Rule (2) was then illustrated and elaborated practically, with especial reference to two and four-cylinder engines and engines employing a four-throw crankshaft as in the eight-cylinder V-type having two cylinder blocks at 90 deg. to each other. Six cylinders is stated to be the smallest number with which the condition of Rule (3) can be obtained. For eight-cylinder-in-line types, when Rule (1) is observed with respect to the center line of the engine, the application of Rule (3) will establish reciprocative balance.

In conclusion Mr. Moyer said that the final step in obtaining a most perfectly balanced engine is the production procedure in balancing or correcting for minor errors existing in the parts as produced. All revolving parts should be placed in refined rotative balance, residuals of less than 0.5 oz.-in. being feasible in production. In some instances the process of balancing may necessitate clamping to the crankpins an allowance for reciprocating parts at the time the work is done. Reciprocative parts such as pistons and pins should be standardized in weight as closely as possible, ± 0.125 oz.-in. representing a corresponding degree of refinement. Connecting-rods should be standardized within similar limits, taking the weight of each end separately, when balanced horizontally on knife-edges at the center of the other end.

In the discussion, J. L. Larson's questions brought out Mr. Moyer's opinion that the elimination of vibration in the 60-deg. V-type engine is largely due to the frequency of the explosions and the torque distribution with uneven intervals; that an engine will vibrate, if out-of-balance, even when revolving without any power other than that due to revolution itself; and that, considering two badly balanced four-cylinder engines as constituting the eight-cylinder V-type engine, even though it be no better than either of the fours with respect to vibration, so far as moving parts are concerned, when torque is included, it will still be superior to the four-cylinder engine although there is no perfectly balanced condition.

Questions also asked by Chairman A. W. Scarratt, G. B. Carroll and others, induced answers from Mr. Moyer to the

[5] See THE JOURNAL, October, 1922, p. 368.

effect that a four-cylinder opposed-type engine with a conventional four-cylinder crankshaft would not be in perfect balance but would be balanced except for rocking couples due to vertical inertia of the connecting-rods; that, comparing an eight-cylinder-in-line engine having nine crankshaft supports with a 60-deg. V-type 12-cylinder engine having three crankshaft supports, the former would have the more perfect balance since the engine itself is capable of perfect balance and disposes the journal bearings so as to prevent the crankshaft from springing out-of-line; and that much of the effort made in the past to obtain perfect mechanical balance of an engine, especially one of the six or eight-in-line type, has been defeated because of inability to obtain proper carburetion and distribution.

Other questions and answers had to do with the firing order of multi-cylinder engines, failure to prevent vibration in a shaft not in rotating balance by the addition of another main bearing, the vibration damper, ability of an oil-film in a bearing to support heavy loading and kindred topics.

Air-Cushions Used as Springs

A pneumatic cushion is the most effective shock-absorber known. This statement appears in the paper presented by Mr. Van Nattan, following his brief comments on the still general use of the multiple-leaf steel-spring in its several different designs and, as proof, he cites the very general adoption of the pneumatic tire. Air-springs for vehicles were known in 1830, but the idea of using an air-spring in connection with the standard leaf-spring was not conceived until 1906. The development of the air-spring business was not really begun until 1914.

Three types of air-spring are on the market. In the single-action type, the shock is transmitted against an air-chamber and the moving piston-member is not controlled as to the rebound of either the compressed-air chamber or the steel spring. The second type is one in which the shock is transmitted in the same manner as in the first type, but the compression pressure in the air-chamber against the piston is partly held in check and the piston has no protection against the recoil of the leaf-spring. In the third type, the shock is absorbed as in the other two types but, in addition, air is drawn into the lower chamber below the piston and controls both the recoil of the upper chamber and the rebound of the steel leaf-spring.

In the first of the three methods used to take care of the great driving-strains, a piston-rod runs through a long bushing and has the leaf-spring connected to a fork on the lower end. In the second there are telescoping tubes, one sliding between an inner and an outer shell, and the leaf-spring is connected to the lower end. In the third method a slide is built below the cylinder and a movable crosshead, connected to the end of the leaf-spring and loosely connected to the lower end of the piston-rod, is placed in this slideway.

Mr. Van Nattan says that a properly designed air-spring should have an accordion-joint between the end of the leaf-spring and the car frame and that such a connection, with one air-spring on each end of each leaf-spring, will allow the wheels to follow the contour of the road while the car itself floats along, suspended on cushions of air. His claims of advantages for air-spring suspension include reduction of excessive vibration above the leaf-springs, prolonging the life of the engine; additional tire-mileage because the tires stay on the road and hence, due to increased traction, additional car mileage per gallon of fuel; protection to the car body and added comfort.

Subjects considered in the subsequent discussion by Messrs. Scarratt, Moyer, Harrison and others had reference to the use of air-springs on motorbuses and trucks, the merits of front and of rear attachments of air-springs, their use in connection with snubbers, operating tests of air-springs, the possibility of replacing the leaf-spring shackles with air-springs, air-leakage of the air-spring cylinders and longitudinal versus cross-spring suspension-systems.

At a meeting of the Governing Board of the Minneapolis Section on Dec. 5, the appointment of A. W. Scarratt as vice-chairman of the Section for the year 1923-1924 was approved.

PROBLEMS OF THE BRITISH INDUSTRY

H. L. Horning Gives Milwaukee Group Benefit of His Observations Abroad

H. L. Horning

Believing that engineers need a broader and more intimate contact with human nature and the world to know their market and to be able to fill it with sympathetic intelligence, H. L. Horning, of the Waukesha Motor Co., outlined for the Milwaukee group general conditions, production problems and engineering and design tendencies as he found them in Great Britain on his recent trip abroad.

According to Mr. Horning, the first thing that greets one's eyes in England is the unemployment situation. There are 1,300,000 receiving Government doles and, during the coming winter, this number is expected to reach some figure between 1,800,000 and 2,000,000.

English Cars Built to Last

It is apparently a well-established tendency in England to buy a car to last. English manufacturers, therefore, take more pains in production than do American car builders, for it seems to be the American ideal to have a new car as often as fashions change. The British also take better care of their cars, treat the mechanism with more respect and have more and better garage mechanics per car than we have on this side.

The cost of gasoline is high, $0.40 per gallon in 5-gal. tins. It makes the question of miles-per-gallon mean something.

The cars themselves are small, but even one of these "vest-pocket" cars in runabout form sells for $750. There appears to be a great difference, relatively, between the buying power of the British public and the price asked for fine cars. Few people here realize this great disparity between the buying power and the prices of automotive apparatus in foreign countries.

Huge Buying Power of American Public

We do not appreciate the buying power of our own people. There are more cars in Wisconsin than in any foreign country in the world, except France and Canada, according to Mr. Horning. In 1925, there probably will be more cars in Wisconsin than in Canada. There are five times as many cars in Wisconsin as there are in Germany. In Illinois and Wisconsin, there will be, on Jan. 1, 1924, more cars than in all the world outside the United States. Wisconsin has more cars than England, Scotland, Ireland and Wales. The surplus capacity that now exists for building motor trucks in the United States is sufficient to replace all the horse-drawn vehicles in Great Britain in 6 months. Motor-car agencies in Great Britain carry as many as five makes of car because the business in a reasonably large territory is not enough to support them on fewer makes. It is, therefore, necessary to carry cars that will appeal to different strata of the buying public.

High Overhead and Low Output Twin Problems

Overhead is the great problem of old nations, for as traditions gather and cling they make progress slow and expenses high. Old employes are kept on the payroll largely for sentimental reasons. Indirectness and other barriers to prompt action help to build up high overhead.

Low output is another feature of the British automotive industry that impressed Mr. Horning forcefully. Factories are

equipped with excellent machines, many of them American. Well-designed jigs and tools are in evidence, but the product is not forthcoming. In the building of engines, for example, the output per man per hour is from 2.5 to 3.0 times as great in America as in England. The price of American engines, because of this quantity production, can be set low enough to compete with English-built engines, even with a 30-per cent duty and freight added.

The British mechanics are handicapped by working conditions unfavorable to large output. These include lack of sunlight, due to the position of the British Isles on the globe, inadequate heating facilities in homes and factories, humidity and muggy weather in summer and poor ventilation. Mr. Horning pointed out that, under these conditions, the wonder is not that production is low, but that it is as high as it is.

Great Britain is also suffering immeasurably from restricted production. It is economically unsound to pay more for a commodity than it is worth, to limit production from a given investment or to raise the price artificially above an intrinsic or demand value.

Mr. Horning found production methods abroad far behind those in the United States. Although, in English factories, interchangeable manufacture made great progress during the war, it is still in the development stage, about where we were in 1906. Files are still one of the most popular tools and are a great standby in production. In many factories, engines are still being completely assembled by one man. In the factory of one of the oldest and most respected firms, they are making cranks from the solid for about $89 each. Difficulty in satisfactorily balancing the forgings was encountered, but they were not interested in installing an American balancing machine because of the investment cost. In both France and England, the largest output is of cars produced and sold by American methods.

Economy of Operation a Design Fundamental

Because of the price of fuel and the general earning power of the people, economy of operation is of great importance in design. Small cars and small engines have been highly developed. Both the French and the British use high-compression engines and suitable fuels of every variety and smell are available at high prices. Steam buses are disappearing, but steam trucks burning coal are still driven on the streets of London.

The demand for light cars has led to a wider use of aluminum castings for crankcases and oil-pans than in America. English engines are also generally lighter than ours, and English builders are beginning to use lighter connecting-rods, hoods, radiator covers and details about the car.

Four-cylinder cars are widely used, but relatively few sixes are seen. Because of the necessity for lower first costs, six-cylinder engines are used only in cars of the highest class and price. Enclosed cars are only just beginning to be appreciated, although it seems strange that, in a country with a climate like England's, closed cars have not found more favor. It is probably a question of economy, like the popularity of the motorcycle. The lighting equipment of English cars seems very weak, and the lights are far less glaring than in America.

Camshaft timing has a tendency to favor high speed, yet with a depression under the base circle, very little extra spring pressures are necessary. In one car, the maximum clearance between push-rod and valve was 0.125 in. Difficulty has been experienced in setting clearance in these cars because it is out of standard practice.

The British air industry is devoting considerable research to those parts of the engine giving trouble at high power output due to high temperature, such as valves, pistons, sparkplugs and hot-spots in the combustion-chamber. One supercharger Mr. Horning saw gave 165 lb. per sq. in. brake mean effective pressure on straight benzol. An effort to produce large cylinders is being made. The largest has developed 150 hp. per cylinder in the Ricardo cross-head type of engine. Floating unsplit bearings have been found to give great satisfaction on highly loaded journals.

On high-speed engines a larger clearance between the valve and the side of the valve chamber has given higher volumetric efficiency, and higher speeds have been accomplished by the use of masked valves. Small valves with high lifts are popular among the better English engineers. Bronze valve-guides are found very effective in high-speed engines.

A tendency to use both exhaust heating of the hot-spots and general heating of the intake with hot water was noticed. These two are used in combination, taking advantage of both for particular circumstances.

Increased Interest in Easy Shifting

Interest in easier shifting from one gear to another with less noise on all gears seems to be growing. To this end, one transmission of the epicyclic type is being developed by one of the leading builders of motor cars. This design has four speeds forward and a reverse. With fairly large clearance of gears, it runs quietly on all gears and gives excellent performance under all conditions of traffic. In fact, the more difficult the conditions, as measured by sliding gear standards, the better does it show up. The ability to shift easily on a hill, going up or down, to use the engine as a brake seems to be of great interest in both Europe and America at this time, and interest in gear-shifting from the steering column is seen.

The laboratories in Europe are far more interested in economy than in power. The European motorist gets acceleration on third gear and runs on fourth. This offers more opportunity for the improvement of the fuel consumption than many of the methods we try. In Europe, an engine running on high has its throttle pretty well open; in this Country, it is very nearly closed. One hears of an occasional performance of 50 miles per gal., but 40 miles is not uncommon.

According to Mr. Horning's observations, our designs are mechanically better than the foreign, but the European engineers pay more attention in their work to fundamentals of thermodynamics and their test procedure is more thorough than ours. English engineers seem to know less of the business and sales end than our men, but they are more thoroughly grounded in mathematics and physics, while our engineers seem to have a better idea of chemistry and the economics of production.

In closing, Mr. Horning emphasized his conviction that the earning power and value of engineers vary directly as their understanding of people, their moods, needs and demands. Americans have much to be thankful for, he pointed out, because their Country is not hide-bound by ancient traditions and they can live in the present in hope of better things in the future where great natural wealth and liberal institutions make for unlimited opportunities in an almost unlimited home market.

The Milwaukee group will not meet in January.

WIDER USE OF PETROLEUM URGED

Need for Development and Expansion Stressed at Petroleum Institute Meeting

An optimistic view of the petroleum industry's future was expressed by President O'Donnell in the opening address of the fourth annual meeting of the American Petroleum Institute in St. Louis on Dec. 11. In reviewing the growth of the industry he called attention to the tremendous development witnessed during the last few years. He felt that the difficulties experienced, such as the present over-production with attendant price-decrease, only serve to strengthen the various units by making them economize and function more efficiently.

The American Petroleum Institute, which has reached a position of importance as a great national organization, helps to stabilize conditions by concerted action of and closer contact between the member bodies.

President O'Donnell warned against State or National bureaucratic control and stated that such action would invite concentration into bigger hands, the larger companies. This would discourage individual initiative. He said that with

few exceptions the industry has been handled wisely and well and that continued development and prosperity are to be expected.

Utilization of Petroleum Products

Utiliziation was perhaps the outstanding topic of the meeting. Henry L. Doherty criticized the industry for having failed to make greater efforts and expenditures toward the development and the expansion of the possible uses of petroleum. He stated that it should be possible to market all the oil now produced and still increase the annual revenues by $1,000,000,000. This would call for assistance to inventors and manufacturers of oil-burning apparatus, the stimulation of oil companies to develop all possible demonstrated applications for oil utilization and the cooperation of those in the industry in developments that individual companies for competitive reasons cannot undertake alone. Mr. Doherty also recommended such changes in the basic methods of crude-oil production as would make possible the blocking out of the raw product so that it could be made accessible only when the market was able to absorb it.

Development of New Uses Advocated

Among the applications mentioned by Mr. Doherty and others as being susceptible of great development were: the burning of oil in locomotives, also discussed by J. M. Johnson, fuel agent of the Missouri-Kansas-Texas Railroad; ship-propulsion, also covered in a paper by J. E. Sheedy, vice-president of the Emergency Fleet Corporation; and house-heating, treated by C. H. Chalmers, Chalmers Oil-Burner Co.

Oil Famine Not Expected

President O'Donnell, Mr. Doherty and other speakers stated that they had ceased to expect a shortage in crude-oil supply within the next few years. It was believed that new sources would be found and that prospects of a famine are very remote.

Automotive Engineers Participate

It is pleasant to note the growing tendency of engineers in the petroleum and automotive industries to meet on common ground for the frank discussion of problems of mutual concern. As at past meetings of the Institute, the fuel and lubrication problems were discussed freely by representatives of both industries. Several of the papers presented at the various sessions are abstracted below.

What is Good Gasoline?

In a message read by Dr. H. C. Dickinson, Director Burgess of the Bureau of Standards expressed warm appreciation of the prompt and generous help given by the American Petroleum Institute and the National Automobile Chamber of Commerce to the injured and the families of those who lost their lives in the recent accident that involved the staff employed at the Bureau on the cooperative fuel-research program.

As to the subject, "What is Good Gasoline?" it was recognized that only an approximate and indefinite answer can be given. To the user good gasoline means a fuel that will give minimum inconvenience, but to the United States it means the fuel that will assure the maximum economic utilization of the Country's petroleum resources. Thus the answer depends both upon existing conditions and upon the point of view.

Pointing to the increasing need of industry for a source of accurate technical information, Dr. Burgess invited even closer cooperation with the Bureau in the solving of basic problems affecting the petroleum industry. Among the duties that the Bureau stands ready to perform are the testing of thermometers, pyrometers and volumetric glassware; the standardization of viscosimeters, and the testing of lubircating oils, paint thinners and transformer oils. The activities of the Bureau in determining the Government specifications for petroleum products and in preparing tables of thermal expansion of oils for the industry were also mentioned.

In conclusion, Dr. Burgess emphasized very strongly his desire that those in the industry lend their assistance in the application and the interpretation, in terms of utility, of the results obtained by experts who could not invariably maintain a close contact with the actual industrial conditions.

Further Discussion of "Good Gasoline"

A very lively general discussion of "good gasoline" was opened by Dr. H. C. Dickinson, who presented as "a mark to shoot at" the following proposed features of a fuel satisfactory to automobile users: (*a*) initial-point not below 40 deg. cent. (104 deg. fahr.); (*b*) 20-per cent point not above 100 deg. cent. (212 deg. fahr.); (*c*) 90-per cent point not above 200 deg cent. (392 deg. fahr.); (*d*) sulphur content not over 0.1 per cent; (*e*) must be non-gumming; (*f*) color unimportant, and (*g*) enough gasoline.

Director Manning, chairman of the meeting, called upon those present to give their views.

H. L. Horning, general manager and secretary, Waukesha Motor Co., was in general agreement with the proposal but said that gumming is at least partly chargeable against the engine. He stated that in engines designed for high speeds a certain amount of blowback, with attendant gumming, often prevails. In concluding his remarks, Mr. Horning expressed the opinion that the time has arrived when the results of past research can be put into iron and steel and that the application of many improvements only awaits public demand.

R. E. Wilson, Standard Oil Co. of Indiana, approved of the proposal and commented favorably upon the stipulation of only the few important points of the distillation curve. He felt that no attempt should be made to specify many points on the curve.

W. P. Deppé, president, Deppé Motors Corporation, did not agree that fuel characteristics should be determined from the point of view of the average user. He felt that too much attention is being devoted to "wet mixtures"; this seemed to him like reverting to antiquated methods at a time when "dry mixtures" should receive greater consideration. Mr. Deppé stated that unfortunately his chief engineer was not present to discuss the technical aspects of the problem more fully.

Dr. Bjerregaard, Empire Refining, Inc., wondered why the 90-per cent point was not given as 400 deg. cent. (752 deg. fahr.), or some other value. W. S. James of the Bureau of Standards, in reviewing the reasons for the proposed values, stated that: (*a*) the initial-point was placed at a minimum figure to avoid boiling in the fuel-line and the jet in summer; (*b*) the 20-per cent point was specified, as it has been found to be important in starting and warming under unfavorable temperature conditions, and (*c*) the 90-per cent point, which is important in connection with crankcase-oil dilution, was placed at 200 deg. cent. (392 deg. fahr.) to keep the dilution within reasonable limits and at the same time to allow leeway for increased production.

It seemed to Mr. James that the responsibilities in the fuel situation should be shared by the two industries involved. The automotive engineers could combat the dilution to a reasonable extent, but the petroleum engineers should give attention to such features as gumming, over which the automotive interests have less control. He felt that the sulphur requirement could easily be met, if not materially reduced. Color should be considered unimportant.

N. A. C. Smith of the Bureau of Mines was not ready to discuss the proposal fully without having had the opportunity of studying the points more carefully. However, he felt that some difficulties might be involved.

I. K. Giles of the Atlantic Refining Co. believed small changes in the initial-point unimportant to automobile users but difficult to control with precision by the refiners. He suggested specifying the percentage distilled at a definite temperature somewhat higher than that of the initial-point.

Dr. G. W. Gray of the Texas Co. thought that the requirements proposed were not sufficiently favorable to the users. He believed the initial-point is of little importance

and suggested that the sulphur content be not over half that specified.

Thomas Midgley, Jr., of the General Motors Research Corporation called attention to the fact that the proposal did not purport to be a definite specification but merely a basis for discussion of features to be desired. He was uncertain whether the initial-point determines boiling and believed that the only way to decide this is to test the fuel with a thermometer. There is little doubt that the user chooses his fuel on a basis of the 20-per cent point or a point nearby, and that crankcase-oil dilution is determined largely by the 90-per cent point. Mr. Midgley believed that certain sulphur compounds in the amount of 0.1 per cent would have very bad effects; this led him to suggest the inclusion of the copper-strip test to cover this point.

As regards item (*g*) of the proposal, that enough gasoline should be supplied, it was felt that with American initiative and industry in action no fear need be felt in this regard, even though other uses for gasoline may arise. If the demand exceeds the production, these new requirements will undoubtedly be met.

Cooperative Fuel Tests

Progress in the fuel tests conducted at the Bureau of Standards in cooperation with the American Petroleum Institute, the National Automobile Chamber of Commerce and the Society was reported in a paper on Economic Motor-Fuel Volatility, by S. W. Sparrow of the Bureau. This covered the results obtained since the 1922 progress report was presented before the Institute. The procedure and some of the material included in this paper were given by the late Stephen M. Lee in his paper printed in the July, 1923, issue of The Journal.

The object of the fuel investigation was to obtain data to show the effect of changes in fuel volatility upon the performance of automobiles now in service. The point to be determined was whether the overall cost of transportation would be reduced by the use of a fuel of lower volatility, fuel *D*, for example, instead of one of higher volatility, such as fuel *B*. The volatility of fuel *C* was intermediate between that of *B* and *D*, while that of fuel *A* was even greater than that of fuel *B*.

In view of the fact that the summer road-tests first conducted showed differences in fuel consumption much less than the estimated difference in the production of fuels, it was necessary to make comparative tests to show the fuel consumption in winter, the rate of crankcase-oil dilution and the ease of starting.

Again, in the winter road-tests no great differences in performance of the two fuels were noted. Hence, laboratory tests with one of the engines using the two fuels *B* and *D* were conducted. Facilities were provided for a wide range of air and water temperature.

LABORATORY TESTS

In these tests a very marked decrease in the fuel consumption per indicated horsepower was noted with a temperature increase at low loads and speeds; this is accounted for by more complete vaporization or better distribution.

Runs were made to show the needle-valve settings for the leanest mixture at which the engine would operate and for maximum power. It was demonstrated that the position of the needle-valve is a poor indication of the fuel-air ratio; for a wider opening of the valve in winter than in summer does not mean that the fuel-flow has increased as much as would have been the case for an equal opening in summer. It was shown that with the conventional type of carbureter the decrease in fuel-flow with decreasing temperatures is due primarily to the increase in the viscosity of the fuel with the lower temperatures. Fuel consumption during the tests did not change greatly with changes in either temperature or fuel (*B* to *D*).

DILUTION

In connection with crankcase-oil dilution, it was pointed out that measurements of the percentage or dilution and of the viscosity are both of interest. The analysis of diluted oils showed that changes in Saybolt viscosity resulting from increase in dilution depended in amount upon the amount of dilution prevailing before the increase occurred; thus the change in viscosity accompanying an increase in dilution from 2 to 4 per cent was greater than that when the increase was from 4 to 6 per cent.

All tests under different conditions showed the percentage of dilution to be greater with the *D* than with the *B* fuel. The jacket-water temperature was found to have a much greater influence than the air temperature upon the rate of dilution. With the same air and water temperatures maintained at full load and part load the dilution was found to be nearly proportional to the load. The tests indicated that small increases in the temperature may reduce the viscosity of the oil as much as a large percentage dilution.

ACCELERATION

The acceleration runs were intended to show whether the rates of acceleration at a given temperature are different for the two fuels and whether the fuel consumption is different for the two fuels in runs during which the carbureter settings are such as to give the maximum acceleration with each fuel, while the speed and the load are kept constant.

For the acceleration tests a disc whose inertia added to that of the armature equaled the inertia of the car from which the engine under test was taken was mounted on the dynamometer shaft. The method of test was such as to reproduce the most severe condition of acceleration, that is, from a load and a speed hardly greater than idling.

At the higher temperatures no difference was found in the acceleration rate for the two fuels, but about 15 per cent more of *D* than of *B* fuel was required at the lowest temperature. In the runs thus far completed, the maximum acceleration was obtained with about the maximum power-setting and with low rather than high air-temperatures.

Important conclusions based upon a great many laboratory and road tests of several engines were as follows:

(1) *Operation under constant speed and load.*—In general the same power and fuel-economy were obtained under warm conditions with fuels *B* and *D*, the latter being the less volatile. Under cold conditions, particularly at low loads, the consumption of *D* fuel was greater than that of *B*, but not as much greater as the estimated possible production

(2) *Acceleration.*—Under warm conditions, very nearly the same rate of acceleration was obtained with the *D* fuel as with the *B*. Under cold conditions, more of the *D* fuel than that of the *B* was required for maximum acceleration. This means a higher mixture adjustment, causing an increased consumption of *D* fuel, but not as much increase as the estimated possible production

(3) *Crankcase-Oil Dilution.* — Crankcase-oil dilution was greater with the *D* than with the *B* fuel. Final decision as to the relative merits of the two fuels hinges upon the evaluation of crankcase-oil dilution. Even in the absence of proper carbureter adjustments with changes in the air temperature, it is probable that 15 per cent more miles per barrel of crude oil would be obtained with the *D* than with the *B* fuel. If a 50-per cent increase in dilution represents an economic loss greater than a 15-per cent mile gain in mileage, then the use of the *D* fuel is undesirable; otherwise the reverse is true. This is the evidence for the accumulation of which this investigation was initiated. Judgment as to the economic fuel rests with the industries concerned

Progress of Anti-Knock Fuels

Without discussing in detail the development by General Motors Research Corporation of the tetra-ethyl lead anti-knock compound, Thomas Midgley, Jr., called attention to the wonders and almost limitless application of the phenomenon of combustion. He described in some detail the action within an internal-combustion engine cylinder.

In this connection he spoke of the limitation imposed by present fuels upon the design of engines and explained briefly how the troublesome knock has been eliminated by introducing into the fuel 0.1 per cent by volume of the anti-knock compound. At the present time the ethylized fuel is being marketed in the amount of approximately 1,000,000 gal. per month, from filling-stations scattered from the Mississippi River to Wheeling, W. Va.

The discussion of Mr. Midgley's paper brought out the fact that with the engine properly redesigned to use ethylized gasoline, the mileage for a given quantity of fuel can be doubled. Without the structural changes, the economy may or may not be improved, but the knock is nevertheless eliminated.

It was stated that tetra-ethyl lead decomposes at 125 deg. cent. (257 deg. fahr.); also that the distillation values of the fuel remain unchanged after the addition of the compound. Mr. Midgley predicted that the present premium of 3 cents per gal. for ethylized fuel could perhaps be reduced within a few years to about one-third of that amount.

Service Tests of Lubricants

Performance of materials in actual service was advanced by W. S. James in his paper on Service Tests of Lubricants in Automotive Engines, as the final criterion by which the suitability of such materials should be judged. He discussed in detail the problems of engine lubrication, as well as methods for making both laboratory and road tests to determine the relative performance of different lubricants. In this analysis he pointed out the difficulties involved in making such tests and interpreting the results in terms of lubrication to the exclusion of other effects.

FACTORS INVOLVED IN LUBRICATION

Among the obstacles to the ideal functioning of a lubricating oil are: (*a*) loss of certain components through vaporization; (*b*) oxidation; (*c*) corrosion of metals; (*d*) entrance of oil into the combustion-chamber, depositing undesirable residues; (*e*) losses from the crankcase; and (*f*) absorption of water and fuel. In actual operation the changes of the lubricants become apparent in power output, specific fuel-consumption, lubrication effectiveness, stability of lubricant, rate of oil consumption and deterioration of the parts.

In engine tests of lubricants the engine may be considered as an apparatus that subjects the oils to a series of "heat-oxygen-metal" conditions which result in changes both in the oil and in the engine itself; the most important changes in the oil being those that result from the action of high temperature and oxygen.

TEMPERATURE EFFECTS

To illustrate the fact that the stability of different oils should be investigated under the same extremes of temperature as those approximating average operating conditions, Mr. James showed a picture of a metal rod that had been brought to a red heat at one end and cooled at the other, while oil was dripped along its entire length. Near the relatively cool end, 212 deg. fahr., was found a film of oil that felt slippery to the fingers; moving toward the hot end the oil became (*a*) gummy, (*b*) like a shiny varnish, (*c*) a black carbonized deposit, (*d*) a nodule formation, and (*e*) a sharply reduced carbon deposit. This demonstrated the obvious unfairness of comparing different oils at different temperature conditions. This same effect of temperature upon carbon deposit was also brought out by reversing the direction of flow of cooling water through an engine. In this case the location of maximum carbon-deposit was reversed from the first to the fourth cylinder.

INFORMATION FROM ENGINE TESTS

In a summary of material and information obtainable from engine tests of lubricating oils, the following were enumerated: heat-oxygen-metal treated oil samples, rate-of-wear data, data on the change in friction losses under different conditions and data on oil consumption.

Service tests of lubricants made with cars in service on the road should be considered as complementary to those conducted in the laboratory; neither type of test alone tells the whole story. The road tests are valuable in showing the range of conditions prevailing in actual use but they do not reveal the reasons for differences. Road tests give the relative importance of numerous factors in engine operation. On the other hand, dynamometer tests, in which conditions can be regulated with some precision, help to explain the differences and to identify the conditions that are met in service.

OIL SPECIFICATIONS

Listing the 14 tests usually applied to lubricants in the chemical laboratory, Mr. James stated that only the following four items probably are involved in considerations from the point of view of the engine: flash and fire represent volatility; viscosity and power measure fluidity; color is possibly a measure of foreign matter; emulsion, demulsibility, acidity, precipitation, high temperatures, carbon and possible water-oxidation indicate stability at low temperature.

DYNAMOMETER TESTS

The five items that should receive careful consideration in oil tests are: the object of the work, the selection of the oils, the selection of the engine or car, the selection of the engine operating conditions and methods of test and the examination of the samples.

The first two items require no discussion. The engine should be chosen with a view to ruggedness, dependability and accessibility; certain features, such as cylinder-head, exhaust-valves and piston-rings, should be such as to bring about conditions of reliable and consistent operation.

As regards engine operating conditions the question to be answered is, What changes have taken place in the oil during test? Temperature is again an important factor. A first comparison of the oils should be made under severe temperature conditions; then, if important differences are noted, the tests should be repeated under less severe conditions. The suitable length of run may be determined by a consideration of the rate of oil consumption, rate of circulation and volume of oil existing. In actual tests, the change in one of the oil characteristics has been found to be consistent with the number of cycles of use. As regards sequence of runs, the different oils should be tested against a reference oil so as to eliminate so far as possible the changes of the engine.

By driving the oil and water-pumps separately from the engine, improvements are noted in starting, warming and regulation to the desired operating conditions. The engine load may well be adjusted, not by the dynamometer load, but by throttling the intake-manifold pressures, that is, by controlling the weight of air entering the engine. Thus a change in the output is traceable to a change in the friction load and is chargeable to the oil. Fuel consumption should be carefully maintained constant. Care should be exercised in cleaning the crankcase.

Samples should be taken at the end of each run. Friction runs should cover several temperatures at a given speed or several speeds at a fixed jacket-water temperature. Single runs are difficult to interpret.

ROAD TESTS

The chief value of road tests is the securing of the actual range of conditions under which the oil is used. The fleet under test should consist of permanent units that are as near identical as possible in type and condition. Carbureters should be adjusted equally. The grouping of cars and the periods of test should be arranged so as to give, first, a comparison of units using the same oil under the same conditions. Then further runs should be made with the original oil in one group and the oil to be compared in another. The third period should reverse the oils and the fourth should be a repetition of the first.

Data should be obtained on mileage, tonnage, fuel and oil consumption, maintenance and care and replacement; weather and road conditions should be noted. Also, an examination of rubbing surfaces is advisable but often impracticable.

Samples will show the relative amounts of wear in various groups. For simplicity they may be averaged mechanically by mixing before analysis.

LUBRICATION TEST CODE ADVOCATED

In concluding his paper, Mr. James urged the formulation of a testing code for internal-combustion-engine lubrication. It was felt that agreement on such a code or method of procedure would benefit materially all concerned.

AUTOMOTIVE AND PETROLEUM INDUSTRIES CAN HELP EACH OTHER

Automotive research and development are in many instances "ahead of the game," in the opinion of H. L. Horning, who delivered a most interesting address on What the Automotive and the Oil Industries Can Do for Each Other. Investigations started both before and during the war, which were pushed most vigorously during the years of the struggle, have now reached a "breathing spell" when results of the work can be applied profitably.

Mr. Horning stated that the most efficient engines and fuels ever known to the world will be brought forth as the public demands them. The anticipated improvements include the doubling of the gasoline mileage attainable, the trebling of the oil mileage and the general betterment of the conditions of automobile operation.

Extension of the uses for petroleum products is an important problem, the solution of which will be of benefit to the petroleum industry and to others; the satisfactory utilization of the heavy ends of the crude oil is one of the outstanding phases of this question. For this, house-heating offers one of the most promising outlets. However, its development from the present stages depends largely upon a more careful study of heat-transfer, radiation, conduction and combustion. In this connection it was stated that the Bureau of Standards is going into these matters thoroughly and deserves the whole-hearted support of the industry in the work.

Mr. Horning spoke of the assistance offered by the automotive to the petroleum industry in replacing obsolete steam and gas-engines now used in the field with more reliable multi-cylinder gasoline-engines of the light, portable type. Twenty-two different lines of business were mentioned as among those in which this change has already taken place. The speaker stated that in many cases it would be found cheaper to buy a new four-cylinder engine every year than to use the obsolete outfits now in operation.

WINTER FUEL ADVOCATED

Further broadening of the markets for both the automotive and the petroleum industries will result from encouraging night driving and winter driving; improvements of highways and lighting will make night driving safer, while the marketing of suitable winter fuels will increase greatly the use of cars during the cold months. Calling attention to the fact that about 75 per cent of the population of the United States reside north of the 40th parallel and that practically 75 per cent of the automotive equipment and gasoline is used by these people, the speaker urged the wide distribution of a winter gasoline adapted to the use of these consumers in their territory where the temperature is below 50 deg. fahr. for 6 months of the year.

Mr. Horning cited the experience at his own plant where statistics had been kept carefully of the number of cars used at different times by employes; those who did not use their cars walked. It was concluded that for every 10-deg. fahr. drop in temperature below 70 deg. fahr., 15 per cent fewer cars were used. While these figures were not presented as the whole story, they were believed to give an unmistakable indication of the influence of temperature on the use of cars. Furthermore, in support of the contention that a winter fuel would be appreciated, it was shown that, within 2 months after the appearance of such a product in Waukesha, 55 per cent of all the cars in the shop had adopted it without propaganda of any kind.

ADDITIONAL PAPERS

In addition to the material outlined above, a number of papers, both technical and general, of peculiar interest to operators, refiners and others engaged in the petroleum industry, but perhaps of somewhat less interest to our members, were presented.

The relation of agriculture and the farm to the oil industry was treated by E. T. Meredith, publisher of *Successful Farming*, and a former Secretary of Agriculture. The use of petroleum and its products for road construction was covered by J. E. Pennybacker, secretary of the Asphalt Association. A most interesting and instructive address on Things Abroad was given by Edward Prizer, president of the Vacuum Oil Co. L. E. Hollins, president of the Associated Advertising Clubs of the World, spoke on The Protection of the Good-Will of the Oil Industry. Several other technical papers also were included in the program.

At the annual dinner President O'Donnell, toastmaster, called upon C. F. Kettering, General Motors Corporation, Julius H. Barnes, president of the Chamber of Commerce of the United States, and A. C. Bedford, chairman of the board of directors, Standard Oil Co. of New Jersey.

REVOLUTIONARY PAINTING METHODS

Pyroxylyn Base Materials and Their Application Discussed at Detroit Meeting

Painting methods and materials that promise to revolutionize the process of automobile body finishing were the subject of another valuable production meeting of the Detroit Section on Dec. 20. The materials discussed are those known commercially as Duco finishes and are manufactured by E. I. duPont de Nemours & Co. Unusual interest was shown by the audience of over 250 men and an incessant cross-fire of questions and answers brought out some exceptionally important points in the discussion. Abstracts of the two papers read by R. C. Williams, engineering representative of the duPont company, and R. S. Rogers, paint superintendent of the Oakland Motor Car Co., are given in the following paragraphs along with a resume of the valuable material presented during the discussion period.

After telling how the new finish came to be developed, Mr. Williams explained that it is essentially a nitro-cellulose solution. Cotton is received in the raw state and put through a purification bath of caustic soda and steam. It is then subjected to a washing and drying process after which it is nitrated to make it soluble in various chemicals, principally the acetates. A small percentage of gums is added to insure adhesion along with the pigments needed to obtain the desired colors and shades. Up to the time of the duPont development it had been impossible to incorporate sufficient solids in enamels of this type to produce a film of satisfactory body. The amount of solids in any pyroxylin solution was limited, since, beyond a certain point, the material became too viscous for practical application and necessitated so much thinning that a prohibitive number of coats was necessary to obtain adequate body and covering qualities. Chemical processes perfected by the duPont company made it possible to increase the amount of solids in the enamels without increasing their viscosity beyond the desirable point.

CLAIMS MADE FOR PYROXYLIN ENAMELS

From the results obtained in production, the advocates of pyroxylin enamels feel justified in putting forth the following claims for this new material:

(1) Is not affected by sudden changes in temperature
(2) Will not check or craze
(3) Is sufficiently flexible to withstand shocks
(4) Forms an impervious film and prevents moisture from coming in contact with the under coats
(5) Dries very rapidly and effects a considerable saving in factory floor space thereby

(6) Can be handled a few minutes after spraying and can be rubbed in a few hours

(7) Colors are stable

(8) Effects an appreciable time and cost saving in the paint shop

Varnish dries by oxidation, but pyroxylin enamels dry by evaporation. When the oils present in a varnish are thoroughly oxidized, the life of the varnish is extinct; on the other hand, when the solvents of a pyroxylin enamel have evaporated, the remaining film has reached a state where its life may be unlimited. This limitation is dependent upon the care and method used in making the application and handling the material.

Mr. Williams stated that his company does not recommend the new material for direct application to steel panels without undercoats, nor is it practical to use it over partially oxidized primers, surfacers and rough-stuff or enamels that are baked at a very high heat. It is rather difficult to remove the oil and the grease from the surface of sheet steel even when chemical solutions and the sand-blast are used. Where traces of the oil remain, the adhesion is certain to be affected adversely. Even on bodies where extreme care was taken to remove the oil with a sand-blast, trouble was experienced and this has led the duPont engineers to recommend the use of undercoats so that good adhesion is assured throughout the entire surface. While some research work has been done on pyroxylin materials for undercoats, it is recommended that the usual primers, rough-stuff and surfacers be used provided they are fully oxidized. The last requirement is an important one; otherwise, the solvents used in the pyroxylin enamel will attack any surplus oil present, acting as a paint-remover and destroying the adhesion of the undercoats. Where high-heat enamels are used, they are baked so hard and smooth that the pyroxylin enamels cannot adhere to them.

As now offered, pyroxylin finishing materials are intended as a substitute for the color and the color-varnish coats, with the option of using varnish as a finishing coat. They are always applied by an air-spray, three coats usually being sufficient to give the proper depth of coat. However, especially where lake pigments are used, it is sometimes necessary to apply additional coats to insure covering properly. For the present, transparent finishing enamels are not being offered. Three degrees of finish are possible with the enamels now in use; dull, semi-luster and lustrous. Dull finish is secured by leaving the surface in the condition it assumes after the last spray coat. Semi-luster is got by rubbing-down and polishing the last coat. Lustrous finish is secured by brushing or flowing on a coat of high-grade finishing varnish after the last enamel coat. While this last type of finish is not recommended by the duPont engineers, Mr. Williams said that there is no serious objection to it.

Description of Oakland Paint System

Practical experience with Duco enamels was presented by R. S. Rogers, paint superintendent of the Oakland plant at Pontiac, Mich. He said that experimental work had proved to the Oakland organization that unusual care must be taken in cleaning the body metal before applying these new pyroxylin materials because of the greater possibility of poor adhesion when even the slightest traces of oil are present. He then gave the following description of the Oakland system of using pyroxylin air-dry enamels. For the first or priming coats, conventional oxide metal primer is used. Both air-drying and oven-drying have been used to dry this priming coat. When using ovens, an air temperature of 250 deg. fahr. is maintained and 80 min. is allowed for the drying time. A period of 24 hr. is needed in the case of air drying, the room temperature being between 75 and 80 deg. fahr. Although the air-drying method proved perfectly satisfactory in production, later tests showed that the enamel was even more durable over the oven-dried undercoats.

Bodies coming from the priming oven are spot glazed to cover file marks, pitted metal and other imperfections. Glazing is done while the bodies are still warm and the sand surfacer is applied immediately, both the glaze and the surfacer coat being dried together in an oven for 80 min. at a temperature of 250 deg. fahr. This plan of application avoided any trouble from one material contracting against the other while drying. Only one coat of surfacer is used since it has been the experience of Mr. Rogers that the fewer coats used under pyroxylin enamels the better will be the result.

R. S. Rogers R. C. Williams

The bodies are next wet-sanded out of the surfacer and air dried. Then they are ragged off with a tack rag and the first coat of enamel is sprayed on at an air pressure of 40 lb. per sq. in., the enamel having a specific gravity of 19. This coat is allowed to dry for 30 min. in an air temperature of 125 deg. fahr. and the body is then left to cool for 15 min. A second coat of enamel is now sprayed on, using the same air pressure and specific gravity as in the first coat. After this second coat, the body is allowed to dry over-night in a room with an air temperature of between 75 and 80 deg. fahr. At this stage the paint surface has a pebbly appearance similar to that of any paint surface which has been applied with a spray gun. Mr. Rogers stated that the pebbly appearance was less marked with low air-pressure on the spray than with high pressure.

How the Surface Finish Is Secured

When the last enamel coat has dried, the bodies are rubbed out with a preparation of boiled linseed oil and gasoline, 7-0 sandpaper being used as an abrasive. Without removing the oil, dry rotten-stone is sprinkled on the bodies and the surface is rubbed until the desired luster and polish is secured. Mr. Rogers is experimenting at the present time with the hope of eliminating this rubbing operation, but he is not ready to announce the final result of his tests. After the rub-down, the bodies are inspected for surface defects and these are bumped out. It is easier to correct defects by bumping the enamelled surface than would be the case if paint were used. Striping is now applied, trimming completed and the entire paint surface is waxed, it being necessary to wax only to protect the striping.

It required 336 hr. to paint an Oakland body with the conventional materials; only 13½ hr. is needed to complete the job when pyroxylin enamels are used. These figures include both the operation and the drying times. The labor time on the paint and varnish system totaled 6.728 hr. per body, but this is reduced to 5.715 hr. with the new materials. Cost of materials in the case of the conventional paints amounted to $2.33 and this has been reduced to $2.26 in the case of the air-dry enamel. These are direct costs only.

Floor Space Greatly Reduced

To appreciate the great advantage of accelerated drying possessed by the Duco material, it is interesting to study the figures given by Mr. Rogers as determined at the Oakland plant in actual production. It required 101,400 sq. ft. of floor area to paint 300 bodies per day when paint and varnish were used; this was reduced to 73,300 sq. ft. when

pyroxylin enamels were adopted. For a production of 300 bodies per day, it was necessary to have 2400 bodies in process of painting by the old method; the new enamel has reduced this requirement to 600 bodies.

Mr. Rogers stated that his experience had also proved that the introduction of the pyroxylin enamels effects a material reduction in the number of finished bodies rejected on account of scratches, mars, poor finish and faded colors. This approximates 20 per cent of the daily production in the average paint-shop but in the case of the enamelled Oakland body this figure has been reduced to 2 per cent. It must be remembered that a skilled painter has to be used on refinishing these rejected bodies whereas the enamel surface can be touched up with a spray gun by an unskilled worker and the added material will dry in a few minutes.

Practical Points for the Pyroxylin Enamel User

An unusually large number of questions were asked the two speakers on the question cards that are used at Detroit Section meetings. Answers to these questions are reported in the following paragraphs. The life of Duco finish has not been determined definitely as yet because some of the bodies first painted with it are still in good condition after 2 years' use. If proper care is taken in applying this new material, it will not peel. Instances where peeling has occurred have been traced to an improper use of the material or unclean surfaces. Rust is not promoted by the ingredients in pyroxylin enamels. They have no tendency to check or crack under ordinary conditions, nor will they crack or become brittle under extremely cold temperatures. The trouble experienced with varnish failure on engine bonnets due to the combined effect of temperature changes and the direct action of the sun's rays has not been encountered with the new enamels. Since the surface of the enamels is much harder than the ordinary paint surface, there is little risk of their becoming scratched when dust and dirt are wiped off with a cloth. Mud-spattered panels were passed through the audience at the Detroit meeting so that the members could try this experiment themselves. Apparently this "dry cleaning" abuse does not mar the surface in the least.

Matching of colors is somewhat more difficult with pyroxylin enamels than with conventional paints, but this may be overcome as the development of the material proceeds. No trouble has been experienced in production due to poorly matched colors on hoods and bodies. Although no definite data were available at the meeting, Mr. Rogers was of the belief that the coefficients of expansion of Duco and steel must be somewhere near the same since no trouble had been experienced from any large difference. Since acetone is used in the chemical solution of pyroxylin enamels, they have a certain amount of paint-remover action. This is not troublesome if the oils in the undercoats are thoroughly oxidized so that they are unaffected by the acetone.

Questions Relating to Application

Some in the audience seemed to feel that the use of pyroxylin enamels carried with it an increased fire hazard. Mr. Williams stated that no fears need be felt in this connection for Duco is no more inflammable than the oils in most commercial paints. One of the members present volunteered the information that he had investigated the matter of insurance and found no increase in rate when pyroxylin materials were used.

Mr. Rogers stated that he had found no material advantage in using an electrically heated spray-gun, although it did tend to take any moisture out of the air supply. W. K. Groff of the duPont organization said that the materials in Duco are non-hygroscopic, that is, they do not attract atmospheric moisture. This nature of the solvents in the pyroxylin enamels defeats any precipitation of moisture due to the rapid evaporation after spraying. It is important, however, to see that the air lines leading to the spray-gun are kept free from moisture. For touch-up work on finished bodies, Mr. Rogers recommended the use of a very small spray-gun that he termed a spot-spray. It only takes an hour or so to instruct a new employe to spray Duco and in 3 days he will attain the same degree of efficiency as the workers who have been handling the material for some time. One of the members inquired about the method of securing a clean division between two colors on the same body when the spray-gun is used. Mr. Rogers explained that this is done in a simple way by putting electrician's tape along the line of division and spraying above or below the tape edge, the tape protecting the color already on the body.

Spraying the Only Means of Application

Because of their rapid drying qualities, pyroxylin enamels cannot be brushed on panels but must be sprayed in all cases. Attempts are being made to flow the new enamel the same as the common fender enamels and Mr. Williams said that this might be a development of the future. Some companies are using as many as five coats of pyroxylin enamel on the body panels with a rub-down between each of the coats. However, the duPont engineers do not recommend numerous coats as their experiments have shown that the fifth coat produces strains in the paint film and the sixth coat actually causes the paint structure to break away from the primer. Thickening the coat does not necessarily increase durability and it may hurt the adhesion of the enamel structure to the undercoats. Room temperatures need not be high to spray pyroxylin enamels successfully; Mr. Rogers has used them without trouble in temperatures of from 50 to 75 deg. fahr. and prefers the latter figure. Although he expressed a preference for the sand-blast as the best means of preparing the metal surface for the primer, the chemical cleansers in general use are perfectly satisfactory. The labor turn-over is increased when the sand-blast is used. It is of no particular advantage to heat the metal surface before applying the enamel coats, according to Mr. Rogers.

Many questions were asked regarding the effects of various materials on pyroxylin enamelled surfaces. It was stated that nitric and sulphuric acids did not harm them unless applied in concentrated form. Varnish removers will destroy a Duco surface because the chemicals in these preparations are practically the same as the solvents used in preparing the enamel. Alcohol anti-freeze solution may be harmful, but Mr. Williams said his experience had shown that the alcoholic-content evaporated so rapidly that it did not have time to start a chemical reaction. The pyroxylin film is not affected by ammonia.

Refinishing Bodies With Pyroxylin Enamels

Mr. Williams stated that the refinishing of bodies which had been painted originally with Duco was a simple matter since this material formed an ideal foundation for the new coats. Light coats should be used in refinishing work to avoid the troubles caused by thick films that were mentioned in a previous paragraph. A perplexing problem is faced in removing the old coat of finishing varnish from the Duco undercoats where the original paint job included a luster coat of finishing varnish. Varnish removers are out of the question because they will attack the pyroxylin materials. L. V. Pulsifer suggested that solvents must be used that will attack varnish but will not affect the enamel underneath; he thought benzol or toluol might be tried. Mr. Rogers offered his answer to this problem by saying that he had found a solution of Duco solvent, gasoline and linseed oil in equal parts entirely practical. This solution is applied to the varnish surface which is then rubbed with 7-0 sandpaper until the varnish is cleaned off. Mr. Williams said that the duPont company considers the matter of refinishing as an important field and intends to foster the establishment of Duco refinishing stations throughout the Country.

Cost data given in the formal papers were supplemented by the answers to some of the questions. The present price of pyroxylin enamel is about $4 per gal. and the solvent or thinner costs $2 per gal. Since the solution used in the air-spray is about half enamel and half thinner, the average cost is $3 for the mixture of the two. The cost of these materials is largely dependent upon the market price of the fusel oil that is used in preparing the solvents. It takes 2 min. longer to spray a body with pyroxylin enamel than to spray it with the conventional materials. At the present time it requires 2 hr. to rub down a Duco coat on an open

body, but Mr. Rogers has developed methods that are expected to reduce this time to 20 min. in the near future.

Source of Supply Will Be Adequate

In some quarters a feeling exists that materials for pyroxylin enamels do not exist in quantities sufficient to insure an adequate supply if these enamels come into general use. These fears were set at rest by W. K. Groff of the duPont company. He said that the solvent situation had been causing some concern in the past, but that this was improving. No trouble whatever is experienced in securing the other ingredients in ample quantity. An inference that the duPont company was using up surplus war material in the manufacture of its body enamels was denied emphatically by Mr. Williams. Mr. Groff said that so far as materials were concerned there was no limitation on the production of pyroxylin enamels in sufficient quantity to supply the automotive industry's demands; it is entirely a question of extending the chemical manufacturing facilities.

L. V. Pulsifer, chief chemist of Valentine & Co., spoke briefly on the attitude of the varnish makers toward pyroxylin enamels. He said that the interest in the subject reflected at this Detroit meeting showed that the industry was taking seriously the matter of body finish durability. This has resulted in the purchase of better varnishes by some companies with the result that several cars are now marketed with body finishes that can be expected to last 2 years. He said that his company is watching the pyroxylin enamel development closely and has done considerable research in these materials with the intention of introducing an enamel of this character some time in the future.

No meetings will be held by the Detroit Section in the month of January because of the scheduling of the Annual Meeting of the Society in Detroit, Jan. 22 to 25. Meetings will be resumed Feb. 7.

NEW ENGLANDERS MEET AT WORCESTER

New England Section members enjoyed the privilege of thoroughly inspecting a large drop-forging plant and hearing a paper on steels for drop-forgings at the December meeting of the Section. This meeting was held in Worcester, Mass., and the inspection trip was made through the large forging shops of the Wyman-Gordon Co. John H. Nelson, metallurgical engineer of the Wyman-Gordon organization, read the paper. He described some of the flaws present in commercial steels and explained the careful inspection methods that have been devised to detect them, not only before the forging operations, but during the different stages of forging. Heat-treatments, physical characteristics and methods of forging the steels for different parts were also discussed.

Mr. Nelson said that his company stored all steel billets received from the mills according to heat numbers; steel billets from the same heat or run are always stocked together. Each heat is given an analysis number which is used to guide the heat-treatment of the steel throughout the shop. Careful chemical and physical tests are made on all steel received and a sample from each heat is treated experimentally to determine the exact procedure to be followed throughout the forging process to secure the required results from that heat of steel. Notched bar and repeated impact tests are also a part of the inspection process. He was most emphatic about the necessity of handling each run of steel individually and adopting the heat-treatment best suited to it.

Crankshafts made from slab forgings are unreliable in Mr. Nelson's opinion. He cited an instance where such a shaft failed in an airplane engine during an important race and demolished the machine. The importance of proper distribution of the metal in forgings as they are formed in the dies was illustrated by pictures that showed sections taken through crankshaft gear-blank forgings.

CLEVELAND DURALUMIN MEETING

Aluminum alloy construction was the subject of the Cleveland Section meeting on Dec. 17. R. W. Daniels' paper on Duralumin, given before the New England Section in October, was read at the Cleveland meeting and G. H. Madelung, project engineer in the Glenn L. Martin Co., spoke briefly on the new development, illustrating his talk with samples of the materials discussed.

No meeting of the Cleveland Section will be held in January.

AIR-RIDING COMFORT

How Air-Springs Contribute to It and a Method by Which It Can Be Measured

J. J. McElroy

What handfuls of air held under pressure for long periods in the cylinders of air-springs can accomplish as shock-killers, how they increase comfortableness and how its degree can be measured, were major topics in the paper presented at the Dec. 6 meeting of the Detroit Section by J. J. McElroy, chief engineer of the Westinghouse Air Spring Co., of Philadelphia.

After reviewing the history of air-spring development, Mr. McElroy analyzed the general characteristics of present air-springs before describing more specifically the air-and-steel-spring combination, which has a characteristic load-curve that allows maximum flexibility in the general working range of the axle yet has an increasing resistance to dissipate large shock-loads. By varying the compression volume in the air-spring, the load curve of the combination can be made more flexible or stiffer as occasion demands. Tests show that the steel-spring vibration alone had a duration of 5½ sec. with a period of 87.2 vibrations per min.; the combination, a 3-sec. duration with 60 vibrations per min.

Fig. 1 illustrates the test apparatus. The test is elementary and is not intended as a true example of actual working

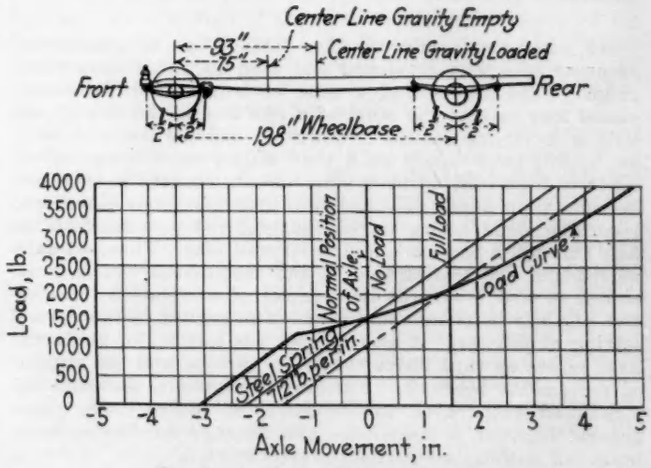


Fig. 1—Air-Spring Test-Apparatus

A Standard Front Dodge Steel Spring Was Hooked-Up with a 2½-In. Direct-Acting Air-Spring So That Either the Steel Spring Alone or Combined with the Air-Spring Could Be Compressed at the Center or Axle Position through a Lever Arrangement. The Spring Suspension Was Given a Constant Load by Applying a Permanent Weight at the End of the Lever and Was then Compressed by Man-Power So That 1½ In. of Additional Compression Movement Was Obtained at the Center or Axle. This Additional Force Was Applied Quickly; Then, the Spring Was Allowed to Vibrate Freely at Its Own Period. The Recording Instrument Is a Paper-Roll That Is Spring-Driven at a Speed of Approximately 15 Ft. per Min., Used with an Electrical Timing Device Marking ½-Sec. Intervals on the Moving Paper

conditions; it is made to bring out the fundamental principle of air-spring suspension and to draw attention to the general characteristic involved in a typical air counterspring arrangement.

Friction in the air-spring is due to (*a*) cup-leather material and design, (*b*) bearing or mechanical with reference to the moving element and (*c*) the lubricant used. Friction is an important factor; for example, rubber packing having an expander spring-tension of 27.5 lb. compared with leather showing a 14-lb. spring-tension in a friction test. In comparing different kinds of oil, tests showed that the friction is less at a lower temperature.

Front-Axle Movements

Field tests of axle movement were recorded by a pen, connected directly to the axle on a motor-driven paper-strip mounted on the chassis, and were made at different speeds over two sizes of obstacle. Curves were also shown that illustrate the axle movement as the car passes over a plank, 5½ in. wide and 2¾ in. high, laid on a cement road. The same characteristic difference, with or without air-springs, was exhibited in each case.

The maximum axle-movement either above or below the normal line is increased when using air-springs, and the subsequent rebound shows more action on the underside of the normal line, the general tendency of the air-springs being to float the chassis on a slightly higher plane at the time of rebound. A reduction in the vibration period and its duration, with increased up-and-down axle-travel, was also indicated by these tests. Table 1 gives the maximum axle-movement values in inches.

TABLE 1—AXLE-MOVEMENT VALUES, WITH AND WITHOUT AIR-SPRINGS

Equipment	Normal Axle Line: Compression Above, In.	Normal Axle Line: Expansion Below, In.	Total Movement, In.
No Air-Springs	1 7/16	1¾	3 3/16
Rear Air-Springs Only	1 9/16	2¼	3 13/16
Air-Springs All-Round	1 13/16	2⅜	4 3/16

[a] Figures given are taken from curves showing the minimum axle-movement on steel springs only and the maximum movement on air-springs all-round. A maximum increase in the amplitude of 30 per cent is shown, due to the air-spring influence. This amounts to 3/16-in. more travel upward on the compression or shock stroke and 5/16-in. more travel on the downward or rebound stroke.

An instrument called by Mr. McElroy an axle-movement recorder was then developed and used on an average rough country-road test-course 1 mile in length and forming a closed loop so that the start of a run is also the finish; one-half is level, one-quarter is down-hill and the last quarter is an up-hill loose sandy road that causes an average car to labor in high gear at 15 m.p.h. The instrument is less cumbersome than paper rolls and is an ingenious consolidation of recording dials acting on one central rod connected to the axle through a bracket and a universal-joint. Thus, all axle-movements are transmitted to the instrument which is designed so that it records the number of movements irrespective of their amplitude and position in regard to the normal setting of the car. It also records the number of times the axle passes upward above the mean position and the number of movements below it. Further, it registers the total accumulated axle-travel, up-and-down, in inches. The same general increase in amplitude and average axle-movements, with and without air-springs, were recorded.

An account was given of other tests conducted on the 5-mile course of the Mason Laboratory, Yale University, at speeds of 20 and 25 m.p.h., and a curve was exhibited to show the relative reduction in axle movement when using air-springs, at such speeds, as compared with using steel springs alone.

At a speed of 15 m.p.h., with the same driver and the same load on all runs and each run duplicated to minimize error, tests were made over a 1-mile Belgian-block course while a snubbing device was in use. The sharp snubbing action of the snubbing device is demonstrated by the reduced axle-movements and its effectiveness is almost negative on this type of road; but the same device used over an average country road shows an improvement in riding quality of 10 to 15 per cent. A rough Belgian-block road will generally show more vibrations and accumulated axle-travel, as both the steel springs and the air-springs must work continuously at faster average intervals with a longer average axle-travel. Generally speaking, the air-spring suspension is at its best and the snubbers are at their worst. The influence of the air-spring is contrasted best at a speed of 15 m.p.h., because the degree of difference in action between the two cases seems then to be at its maximum.

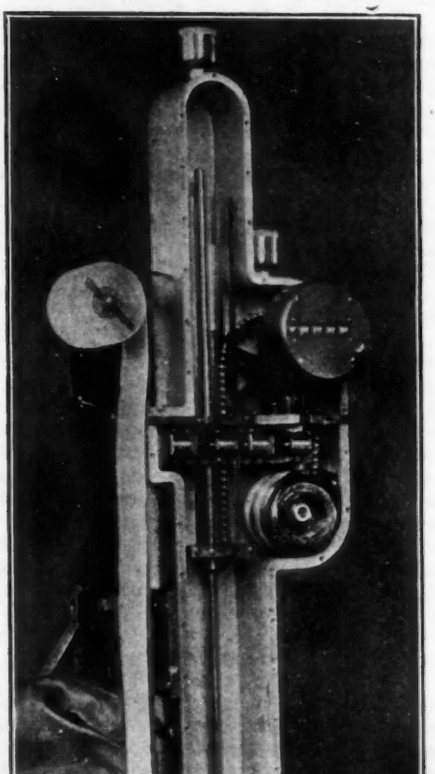


Fig. 2 — The Mechanical Axle-Movement Recorder Which Operates on the Same Principle as a Pedometer

In Its Present State of Development the Device Is Considered Reliable Enough To Give Fair Average Comparisons as to the Relative Merits of Different Spring-Suspensions. The Recording Apparatus of a Pedometer Is Impelled by an Oscillating Weight Supported by a Lever Arm, the Entire Mass Being Nearly Counterbalanced by an Adjustable Spiral Spring

Mr. McElroy stated further that the air-spring increases the total up-and-down axle-amplitude approximately 28 per cent and reduces the amplitude that is above the normal line approximately 29 per cent but that it increases the total amplitude below the normal line by 105 per cent, thus pushing the theoretical normal line or axis of the axle vibration away from the chassis under running conditions only. This tendency to float allows the air-spring combination to have slightly less axle-clearance at rest than would be provided for the steel springs alone. The net reduction of axle-vibration duration, over a period of time, is approximately 16 per cent or say a reduction in axle movement of 5 vibrations per sec.

without air-springs to 4.12 per cent with them. This reduction is a natural function and still leaves the axle free and flexible in both directions, yet capable of very fast action in absorbing shocks and making contact with the ground in depressions. Hence, the general effect is to smooth out the body line of travel and reduce the objectionable vibrations in the chassis and in the body.

Measuring Riding Comfort

In making any road test for riding comfort, the course and the testing instrument are the two constant factors; the speed and the ability of the driver to retrace his course in identically the same path at identically the same speed are the variable factors. A good course should have a variety of different types of road surface, grades both up and down and some turns. It should be of a length that is sufficient to average the human error that is bound to occur when driving.

Fig. 2 shows the instrument used for measuring riding comfort and Fig. 3 is a drawing showing its principal parts. A long throw will show considerable space between the perforations. Short fast snappy vibrations condense the perforations so that a magnifying glass is needed to count them. The entire story is recorded on the tape. By measuring its length, from the first perforation to the last, the accumulated weight-travel is determined; and, by counting the perforations, the number of vibrations is ascertained.

Due to the possibility that the tape may slip, a positively driven counter is used to check-up the tape length; it gives a quick answer and an accurate indication of the results that are to be expected on the tape. The instrument was designed to record each and every vibration exceeding an acceleration of more than 10 ft. per sec. per sec.; this is the *A* factor. Also, to record the movement of the weight upward, but making no attempt to measure the force of the throw directly; this is the *B* factor. The larger vibrations are thus recorded as they occur, as the throw of the weight is governed by the force of the shock.

The general average improvement shown by devices, either of the spring or of the hydraulic type, is 10 per cent; that of the air-spring is 35 per cent. Test results so far seem to indicate that a good spring-type snubber is equally as efficient as an hydraulic type, but it is apparent that a snubber of either design does not decrease the number of vibrations materially. Generally it shows a 2-per cent decrease and, under certain conditions, will increase the vibrations to such an extent that the improvement in riding quality is lost. On the other hand, the air-spring usually will show a 30-per cent decrease in the number of vibrations.

Recently, tests were made on a 1921 open-model car, that has rear-wheel brakes only, and an almost new coupe of the same factory that has four-wheel brakes. The results indicate that an auxiliary device will show a greater improvement of riding quality on a four-wheel-brake car than it does on a car having brakes of the regular two-wheel type.

High-Lights of the Discussion

Question cards from members present were productive of additional information from Mr. McElroy. He said that, under a normal load, between 60 and 70 lb. per sq. in. pressure is carried in the air-spring air-chamber, causing a range under operating conditions of from 30 to 150 lb. per sq. in. As to how long an air-spring air-chamber will hold its air, the answer was 2 months without additional air as an average, although cars have been known to run 1 year without renewal with present air-springs. His statement was that it is too costly to install air springs on a car having rear springs of the cantilever type, because this type of spring must first be rebuilt.

In the course of the discussion, it developed that complete tests and descriptions of an interesting pneumatic suspension for bicycles and automobiles are reported in a paper by Archibald Sharp, an English engineer, its title being Pneumatic Springs for Road Vehicles.[1] The piston cylinders have no contact with one another and are attached with what Mr.

[1] See *Proceedings of the Institution of Automobile Engineers*, vol. 4, p. 97.

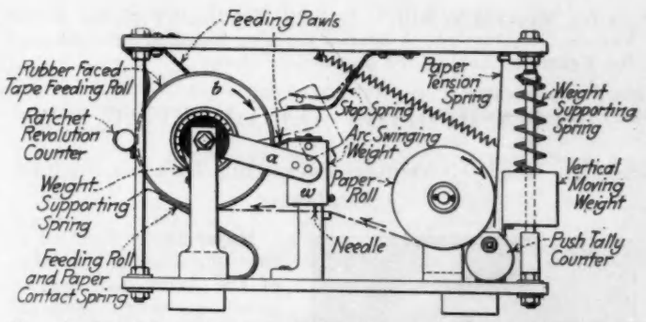


Fig. 3—Principal Parts of the Mechanical Axle-Movement Recorder

The Weight *w* Is 85 Per Cent Spring-Suspended through the Radius-Arm *a* That Is Held by a Flat Spiral Spring Located Alongside the Friction Drum *b*. The Drum Floats on Ball Bearings at the Center and Is Actuated by Pawls to the Radius-Arm So That It Moves Only in One Direction. The Tape Is Pulled by the Rotation of the Friction Drum as the Weight Goes Down; Each Throw Is Recorded on the Tape as It Passes under the Weight, Which Is Equipped with a Pin That Perforates the Tape

Sharp terms a "rolling packing mitten." One side of it is attached to one member, the other side to the other member, and the mitten rolls over itself as a stocking is rolled. Two advantages were said to result, approximate elimination of friction and that air inside the mitten is trapped permanently.

With regard to why it is not possible to get the same effect with a flexible steel-spring as with an air-spring, Mr. McElroy said that the ordinary flexible steel-spring has a constant scale but that the air-spring in combination with the steel spring has an increasing scale of resistance. The basis on which the percentage of riding comfort is calculated was said by Mr. McElroy to be that of simple comparisons. He described the calibration of the instruments already mentioned and discussed further specific features of air-spring design.

FEDERAL MOTOR HIGHWAY RESEARCH

Earl B. Smith at Dayton Meeting Describes Tests by Bureau of Public Roads

For the past 20 years, the scientific side of road-building has had the attention of the Bureau of Public Roads of the Department of Agriculture. At the meeting of the Dayton Section on Dec. 4, Earl B. Smith, testing engineer of the Bureau, described the development of the work that now has 120 types of road construction under test.

As the permanence of a road depends largely upon the kind of material used, the first 10 years of the Bureau's work consisted of material-testing. When the automobile changed the type of road, the structural strength of the road became a factor of increasing importance, as the use of trucks increased. Mr. Smith illustrated his talk with slides showing the instruments developed by the Bureau to test the bearing value of various soils and to register the static and impact force exerted upon roads by the traffic passing over them. The motion picture that closed the meeting showed still more of this test work. Mr. Smith's paper will, it is expected, be published in full in a future issue of The Journal.

The Dayton Section has scheduled a meeting for Jan. 22. At 8 o'clock, after a dinner at 6:30 p.m. in the Dayton Engineers Club. B. J. Lemon, of the United States Rubber Co., will speak on Research in Improving Handling and Utilizing Rubber Latex.

COAST GROUP HOLDING MEETINGS

A group of active Society members in and around San Francisco has been formed to give the members on the Coast the advantages of local meetings enjoyed by those in regular Section territory.

Through the courtesy of Arthur B. Domonske, of the University of California, a meeting in Berkeley has been arranged for Jan. 24, to be followed by a visit to the head-lamp

testing laboratory, with a talk by Mr. Boelter of the Motor Vehicle Department. A special meeting has also been planned for February during the automobile show.

WASHINGTON AERO MEETING

Section Hears Extremely Interesting Talk on Military Airplanes

MAJOR LESLIE MACDILL

Major Leslie MacDill of the engineering division of the Army Air Service gave a very complete summary of advances made in aeronautical development at McCook Field when he addressed the Washington Section on Dec. 7. Unfortunately it is not possible to pubish the most interesting of the material covered in his talk because of its confidential character. He gave many of the details of the latest supercharger developed for great altitude service and also described a new barrel-type engine that seems to possess many advantages for use in military planes.

Motion pictures were shown of pursuit planes going through maneuvers simulating those required in aerial combat, large bombing planes laying smoke screens and attacking battleships and some fascinating scenic views taken from ships flying over the Grand Canyon and the mountain ranges in the West and Alaska. This attractive meeting program drew the largest gathering of members and guests in the history of the Washington Section and demonstrated that interest in aeronautical development is still keen among engineers in general.

The Washington Section will not meet during the month of January.

AVOID STUNTS, ADVICE TO MID-WEST

Successful Automobile Engineer Designs for Average Family, Says E. S. Jordan

EDWARD S. JORDAN

Speaking before the Mid-West Section at its Dec. 14 meeting on What I Know About Engineers, Edward S. Jordan, president of the Jordan Motor Car Co., emphasized the engineer's responsibility for what he says and does and warned his audience against the temptation to "do something different."

Applying his advice to the matter of wheel design, Mr. Jordan pointed out that somebody makes a pretty good wheel now. The thing to do is to take what he has got today and, as you go along from month to month in the production of this automobile, if you find that this man can improve that wheel in any little particular, if you can make a suggestion to him that will help him improve the service of that wheel, that is your job. Do not design or contrive or conceive of some new or different type of wheel because you are an engineer.

If the automobile is to be built for the average family of five, one of them is likely to be a woman. The first thing she does is look. The first thing she sees is color. She puts her hand on the leather, steps in and sits down. She looks around for little accessories, little interesting things, just as she would in a room in your house. To satisfy her is not engineering; it is just common sense. The wise engineer will see that the cushions are comfortably arranged, that the color and other details of appearance are attractive and that the car is well balanced, with good springs, even though they cost more.

DO NOT IMITATE. BUILD FOR THE OWNER

Any salesman or engineer or any business man who starts in business with the idea that he will imitate the fellow across the street might as well go out and get a job selling peanuts; he is licked before he starts. He just cannot get anywhere. If you are following somebody else, you are always behind.

The engineer is building for the owner. He is building for the man he will work for, and that is the man who will make him or break him. The car should be built for that man's family.

The fundamentals an engineer must consider in designing an automobile are appearance, comfort, fair performance, economy, reliability and, above everything else of course, service, because that means second-hand valuation. Within a few years the time will come when for every new car shipped from the factory, the dealer will have to deliver a couple of old ones. If the cars are built without these fundamentals, it will be only a matter of time until the dealers are losing money.

Mr. Jordan gave some unusual advice on setting prices. For successful selling, always have your price a little higher than your competitor, for price is the public measure of value. Always have it a little higher; do not have it lower because, according to Mr. Jordan, the lower price is an admission on your own part that your product is inferior.

The ambition to get a large production and to dominate the trade will lead to some very interesting developments in the next 2 years, if Mr. Jordan's prophecy comes true. It is his belief that the dealer simply cannot stand the gaff, because he cannot finance the trade. In Cleveland during the past year, as Mr. Jordan pointed out, 64 per cent of all the cars delivered were second-hand automobiles, that is the dealer's business. If an automobile cannot be turned the second time at a profit, production will eventually be curtailed on that car.

Commenting on the plan for combination in the automobile industry, Mr. Jordan reminded his hearers that people do not like to be forced to buy from any one individual, manufacturer or group. Mr. Jordan believes that such a combination cannot succeed because brains, style and hard work cannot be cornered.

Asked what he thought of the flat-rate service charge, Mr. Jordan went on record as believing that the movement is entirely in the right direction, although it may be difficult to determine just what the charge should be. What a man wants more than anything else is to have the job fixed and have it fixed right at a reasonable charge.

The Mid-West Section will have no meeting in January.

OIL PROS AND CONS FOR BUFFALO

Engines for Oil vs. Oil for Engines will be the topic of a brass-tacks discussion scheduled for the February meeting of the Buffalo Section. L. H. Pomeroy will present the engineers' point of view and A. Ludlow Clayden, of the Sun Oil Co., will lead the opposition for the lubricating-oil men. Winter contamination of oil and disputed points of viscosity and solidification will be among the topics coming up for settlement. The meeting will be held in the Statler Hotel, Buffalo, at 8 o'clock on the evening of Feb. 4.

William R. Knopp, sales engineer with the Dayton Engineering Laboratories Co., talked on Automotive Electrical Equipment before the Buffalo Section at its meeting on Dec. 3.

Applicants *Qualified*

The following applicants have qualified for admission to the Society between Nov. 10 and Dec. 10, 1923. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff) Affiliate; (S M) Service Member; (F M) Foreign Member; (E S) Enrolled Student.

ARCHER, T. P. (A) vice-president and general factory manager, Ternstedt Mfg. Co., 6307 West Fort Street, *Detroit.*

BLEYLE, C. A. (A) supervisor, Texas Co., 201 Devonshire Street, *Boston.*

BOUTON, EUGENE (M) supervisor of time study, Chandler Motor Car Co., *Cleveland,* (mail) 1716 Hartshorn Street.

BOVEY, THOMAS (A) president and chief engineer, Bovey Automobile Heater Co., 3907 Prairie Avenue, *Chicago.*

BRAMAN, GEORGE H., JR. (J) chief draftsman, Walden Worcester, Inc., *Worcester, Mass.,* (mail) 22 Tampa Street.

BRUSSEL, JOHN W. (M) assistant works manager, Timken-Detroit Axle Co., *Detroit,* (mail) 324 Hendrie Avenue.

BURNS, CHARLES E., JR. (A) mechanical laboratory assistant, Bureau of Public Roads, *City of Washington,* (mail) 130 East Capitol Street.

CHADWICK, LEES W. (A) president, Chadwick-Leclair Co., 3284 Blaine Avenue, *Detroit.*

CHANDLER, HENRY (M) metallurgical engineer, Vanadium Corporation of America, New York City, (mail) 1355 Book Building, *Detroit.*

COURTNEY, HARRY V. (E S) student, Stevens Institute of Technology, Hoboken, N. J., (mail) 42 Crosby Street, *New York City.*

DAY, THURMAN O. (M) master mechanic, Yellow Cab Co. of Philadelphia, 1208 North 31st Street, *Philadelphia.*

DONAHUE, F. J. (A) president, F. J. Donahue Varnish Co., *Detroit,* (mail) 2317 Edison Avenue.

ECCLESTON, J. B. (A) Brandenburg Bros. & Eccleston, *Pontiac, Mich.*

GRABNER, JOHN (J) draftsman, Continental Motors Corporation, *Detroit,* (mail) 2068 East Grand Boulevard.

GROSELLE, JOHN F. (S M) automotive engineer, Ordnance Department, Rock Island Arsenal, Rock Island, Ill., (mail) 729 East Rushmore Street, *Davenport, Iowa.*

GUSTAFSON, A. A. (M) works manager, Yellow Sleeve Valve Engine Works, East Moline, Ill., (mail) 2315 13th Street, *Moline, Ill.*

HODGE, ROY C. (A) purchasing agent, Cleveland Automobile Co., *Cleveland.*

HOOKER, JOHN C. (A) auto service investigator, Bronx Stratton-Bliss Co., *New York City,* (mail) 2490 Davidson Avenue.

HUNGERFORD, FRED STEPHEN (E S) student, Massachusetts Institute of Technology, Cambridge, Mass., (mail) 621 Commonwealth Avenue, *Boston.*

JAMIESON, JOHN STEWART (A) (mail) 2175 Chalmers Avenue, *Detroit.*

JOHN, WILLIAM EDGAR (A) vice-president, Hall Wheel Corporation, 1411 Morris Building, *Philadelphia.*

JORGENSON, CLARENCE H. (A) consulting engineer, Dole Valve Co., Chicago; mechanical engineer, Jorgenson Engineering Co., Chicago, (mail) Illinois Athletic Club, 112 South Michigan Boulevard, *Chicago.*

KERR, ROBERT H. (S M) automotive engineer, Rock Island Arsenal, *Rock Island, Ill.,* (mail) 1508 40th Street.

KLEMENTS, J. M. (J) detailer, Cleveland Automobile Co., *Cleveland.*

KRANZER, EMANUEL C. (A) engineering draftsman, Thomas E. Murray, Inc., New York City, (mail) 881-A Lafayette Avenue, *Brooklyn, N. Y.*

KRIEGBAUM, ASA WALTER (J) student engineer, Remy Electric Co., *Anderson Ind.,* (mail) Y. M. C. A.

KRIETER, HARRY R. (E S) student, University of Michigan, *Ann Arbor, Mich.,* (mail) 733 East University Avenue.

LEVETT CO., WALTER M. (Aff) 417 East 23rd Street, *New York City.*
Representatives:
Lamborn, Henry J., engineer.
Levett, Walter M., president.

LUKS, KRAEMER (A) engineer on technical staff, American Bureau of Shipping, New York City, (mail) *Towaco, N. J.*

MCADAM, D. J., JR. (M) metallurgist, Naval Engineering Experiment Station, *Annapolis, Md.*

MCCORMACK, DENIS (J) engineering department, Brooks Steam Motors, Ltd., 1304 Canadian Pacific Railway Building, *Toronto, Ont., Can.*

MCCREERY, CHESTER M. (M) manager of highway transportation department, Goodyear Tire & Rubber Co., 1144 East Market Street, *Akron, Ohio.*

MEYER, FRED C. (A) stock clerk, Uppercu-Cadillac Motor Car Co., New York City, (mail) 51 Walnut Street, *Ridgewood, N. J.*

PEARLSTONE, PAUL (E S) student, Sheffield Scientific School, *New Haven, Conn.,* (mail) 150 Grove Street.

PERCIVALL, J. J. (M) superintendent of transportation New York division, Gulf Refining Co., New York City, (mail) 142 South Grove Street, *East Orange, N. J.*

PIETZ, LOUIS F. (A) road engineer, International Harvester Co. of America, *Sioux City, Iowa,* (mail) 1015 Jackson Street.

POWELL, ROBERT E. (A) consulting motor transportation engineer, *Onancock, Accomac Co., Va.*

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SAINTURAT, MAURICE (F M) engineer, Automobiles Delage, Paris, France, (mail) 54 Avenue de Neuilly, *Neuilly sur Seine, France.*

SCHELL, CARL A. (M) chief engineer, Thermoid Rubber Co., 1302 Swetland Building, *Cleveland.*

SICREE, ALBERT J. (J) instructor of mechanical engineering, Stevens Institute of Technology, *Hoboken, N. J.*

SMITH, GEORGE L. (M) designing engineer, 2614 Woodley Place, *City of Washington.*

WANG, WILLIAM S. C. (E S) student, University of Michigan, *Ann Arbor, Mich.,* (mail) 727 East University Avenue.

WOOD, ALBERT HENRY (A) automobile engineer, Ruckstell Axle Co., Ltd., *Toronto, Ont., Can.,* (mail) 664 Coxwell Avenue.

Applicants *for* Membership

The applications for membership received between Nov. 15 and Dec. 15, 1923, are given below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ALEXANDER, ALBERT N., industrial engineer, Murray Rubber Co., *Trenton, N. J.*

ALLEY, JOHN H., student, Georgia School of Technology, *Atlanta, Ga.*

AXILROD, J. J., vice-president and general manager, M. J. Ford Mfg. Co., *Northumberland, Pa.*

BEALL, A. L., manager of retail department, Metropolitan Battery Service Co., Inc., *New York City.*

BRATTON, ANDRAL, student, Georgia School of Technology, *Atlanta, Ga.*

BURGESS, LAURENCE EDWARD, student, University of Michigan, *Ann Arbor, Mich.*

CHANDLER, FRED C., JR., assistant to vice-president, Chandler Motor Car Co., *Cleveland.*

COLIN, LEON, N. W., consulting engineer, *City Island, N. Y.*

COUSINS, E. A., sales representative, Westinghouse Electric & Mfg. Co., *East Pittsburgh, Pa.*

COWIE, ERNEST S., president, E. S. Cowie Electric Co., *Kansas City, Mo.*

DAWE, C. NEWMAN, metallurgical engineer, Studebaker Corporation of America, *Detroit.*

DODDS, THOMAS EDWARD, student, Ohio State University, *Columbus, Ohio.*

FERGUSON, GUY M., assistant, material specification and inspection engineer, American Locomotive Co., *Schenectady, N. Y.*

GRANGE, LEO O., service manager, Northwestern Tire Co., *Minneapolis.*

HARRISON, EDWARD P., engineer, Sheldon Machine Co., *Chicago.*

HARTMAN, EUGENE L., engineer, Hartman Supply Co., Inc., *Pittston, Pa.*

HOWELL, F. D., vice-president and assistant general manager, Motor Transit Co., *Los Angeles, Cal.*

HUNGERFORD, FRED STEPHEN, student, Massachusetts Institute of Technology, *Cambridge, Mass.*

KAHMANN, C. H., engineer, Traffic Motor Truck Corporation, *St. Louis.*

KEARNEY, BERNARD J., draftsman, Individual Drinking Cup Co., Inc., *Easton, Pa.*

KELLY, D. V., chief inspector and supervisor of heat-treatments, Beans Spring Co., *Massillon, Ohio.*

KLINKICHT, CHARLES E, electrician, Jost Storage Battery Co., *Jamaica, N. Y.*

LAWLESS, WALTER, mechanical superintendent, Doyle Motors, Ltd., *Toronto, Ont., Canada.*

LECESTRE, H. C., body engineer, Brooks Steam Motors, Ltd., *Stratford, Ont., Canada.*

LOCKWOOD, LOUIS H., treasurer and chief engineer, Lockwood-Ash Motor Co., *Jackson, Mich.*

MAUN, W. E., director of purchases, Yellow Cab Mfg. Co., *Chicago.*

MOEHRING, J. A., treasurer, Gray Tractor Co., Inc., *Minneapolis.*

MONROE, V. W., sales engineer, Prest-O-Lite Co., Inc., *Indianapolis.*

NICHOLSON, STANLEY W., chief engineer, Dura Co., *Toledo.*

PARRILL, FRANK L., sales promotion manager, Prest-O-Lite Co., Inc., *Indianapolis.*

PIERSON, ARTHUR EDWIN, student, University of Michigan, *Ann Arbor, Mich.*

PIPER, J. C., manager, Robert H. Hassler, Ltd., *Hamilton, Ont., Canada.*

PRATT, CECIL F., president and general manager, Sphinx Products Corporation, *San Francisco.*

PRATT, DONALD L., vice-president, Sphinx Products Corporation, *San Francisco.*

RETT, CARL E., chief engineer, Lambert Tire & Rubber Co., *Barberton, Ohio.*

ROFFMANN, HAROLD R., chief engineer, National Collapsible Rim Corporation, *New York City.*

RYCRAFT, CLARENCE A., manager of automotive department, *Democrat and Chronicle, Rochester, N. Y.*

SEEBURGER, WILLIAM E., manager, Community Garage, *Crockett, Cal.*

SMITH, ROBERT R., metallurgist, Robert H. Hassler, Inc., *Indianapolis.*

STEWART, WARREN A., student, Georgia School of Technology, *Atlanta, Ga.*

SWOBODA, HERMAN ALFRED, student, Stevens Institute of Technology, *Hoboken, N. J.*

WANG, HSU, draftsman, Pierce-Arrow Motor Car Co., *Buffalo.*

WANG, WILLIAM S. C., student, University of Michigan, *Ann Arbor, Mich.*

WARNER, A. P., manufacturer, Warner Trailer Co., *Beloit, Wis.*

WATKINS, BENJAMIN E., student, Georgia School of Technology, *Atlanta, Ga.*

WEST, WILLIAM GOLDING, production layout man, Wright Aeronautical Corporation, *Paterson, N. J.*